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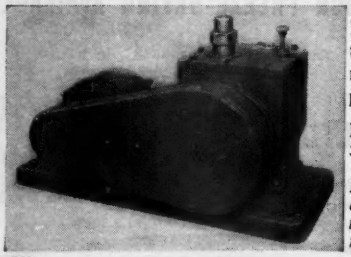

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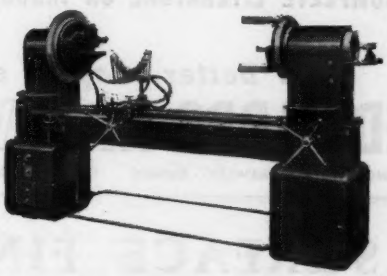

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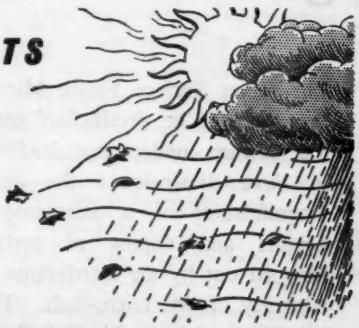

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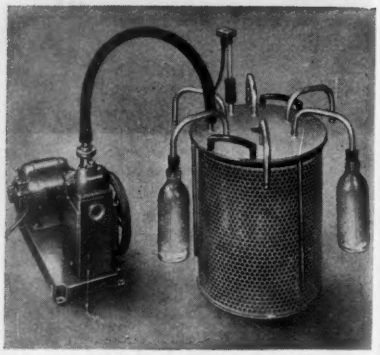

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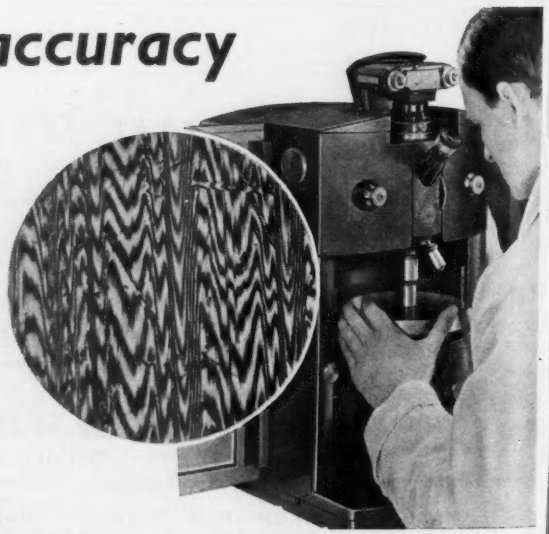

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THE BASIS OF ANGLO-AMERICAN CO-OPERATION

THE proposals for the expansion of education in the United States, and especially of the educational activities of the National Science Foundation, which President Eisenhower outlined in a message to Congress on January 27, form part of the eight-point programme which the President laid down in his State of the Union message to the American people on January 8, and which he further elaborated in his budget message of January 13. They arise also quite logically out of an earlier address on "Science and National Security" on November 7, in which he announced the appointment of Dr. J. R. Killian as special assistant for science and technology, charged with seeing that the President is provided with the best possible advice the scientific community can supply, that full use is made of available scientific and technical man-power, and that the programme of scientific and technical development is efficiently executed without overlapping or inter-service rivalry. Specifically, in the same address, President Eisenhower referred to the legislation to be laid before Congress, in accordance with the agreement previously reached with Mr. Macmillan, to remove legal barriers in the exchange of appropriate technological information with friendly countries, and to his intention to support a scientific committee organized within the North Atlantic Treaty Organization to promote an expanded Atlantic effort in research. Similar action in the South East Asia Treaty Organization and comparable organizations was to be studied, and to assist such measures of mutual effort the Secretary of State would appoint a science adviser to himself and scientific attachés in appropriate places abroad.

In concluding his address on the influence of science on defence, President Eisenhower pointed out that science has much more to contribute than its function in strengthening defences. Its contributions to healing, to the enrichment of life, to freeing the spirit are no less important, and they have their place in the spiritual power of a nation—its underlying religious faith, its self-reliance and capacity for intelligent sacrifice which are vital elements in national strength and defence. Even without that emphasis on science and technology, the interest of the President's messages for the scientist and technologist in Britain is obvious. Co-operation is likely to be uneasy, if not irksome, if there is not the same desire on both sides of the Atlantic to eliminate waste and secure the most effective identification of the critical problems and needs.

The President's messages indicate a fresh determination in the United States to bring the best scientific advice to bear in scientific and technological endeavour. The position in Great Britain, as indicated by a reply in the House of Commons given by Mr. H. Nicholls on December 10 to a question regarding the appointment of a scientific attaché at the British Embassy in Moscow, is disturbing. Administrative arrangements which require the Parliamentary Secretary to the Ministry of Works to reply for the Lord President of the Council show that something is wrong. Were the Lord President's Office properly staffed, it would have been realized how much a qualified man on the spot could have helped Western Governments to take an early measure of the strength of Russian science, if not technology, and to see that the best use is made of the now substantial interchange of scientists between Britain and the U.S.S.R. An official reply, after at least two decades of obvious need, stating that "an appointment of this kind has been considered from time to time and is now being considered again" is inadequate; and it will certainly not assist Anglo-American co-operation.

The structure unfolded in President Eisenhower's message is worth examining with British needs in mind, remembering also that the proposals spring out of a distinctly American background going back at least to the establishment of the National Science Foundation. They can indeed be traced back to Dr. Vannevar Bush's report, "Science—the Endless Frontier", and to the Steelman report, "Science and National Policy", while the financial proposals of the message of January 27 are foreshadowed in the sixth annual report of the National Science Foundation and in that of the Commission on Financing Higher Education in the United States published in 1952.

By and large, it could be said that the proposals are the fruit of the work of that Commission, especially its report on the nature and needs of higher education, of the President's Commission on Higher Education, and of the series of inquiries into the Federal funds and organization for research and development, into man-power and into federal support for science students and into scientific and professional and skilled man-power which both the National Man-power Council and the National Science Foundation have conducted during the past six years or so. They attempt to view education as a whole. Science and technology are seen as part of the educational system, and the attempt to foster their expansion starts—as it should do—in the schools. Here, if nowhere else, is the significance of these proposals for Britain; nor is that significance lessened by the fact that the President's new adviser, Dr. J. R. Killian, comes from the Massachusetts Institute of Technology and was concerned with the outstanding report on academic policy which in 1950 recommended full acceptance of broad educational objectives in which the humanities and social sciences had their place.

The objectives of the educational programme outlined by the President are essentially functions which were entrusted to the National Science Foundation when it was first established in 1950; but the Foundation's pursuit of those objectives was

hampered when Congress rejected the financial proposals originally recommended and limited the Foundation's appropriations to a maximum of 15 million dollars in any year. This ceiling was removed in 1953; but even in 1956 the appropriation was only 16 million dollars, and subsequent increase to 48 million dollars in 1957 was largely on account of the United States participation in the International Geophysical Year. The increase of 64·5 million dollars in the budget of the Foundation now recommended is, however, largely intended to raise the quality of research, training and teaching in the sciences. Its effect on other activities of the Foundation—the support of basic research, its fellowship programme and the exchange of scientific information—is likely to be indirect or qualitative rather than direct or quantitative. Of itself it may do little to remove the conditions to which have been attributed the backwardness of the United States in nuclear fusion, though the secrecy conditions and classification arrangements should be improved as a result of the President's other recommendations arising out of the statement regarding Anglo-American co-operation issued after Mr. Macmillan's visit to Washington last October.

The appropriation now recommended increases five-fold the Foundation's expenditure on activities designed to extend and improve scientific education, and in part it is intended to yield an immediate increase in the number of scientists and engineers. This should result directly from the increase in the graduate fellowship programme of the Foundation, on which 2·13 million dollars was expended in 1956—925 fellowships were awarded for 1956–57. For education in the sciences, the Foundation appropriated 1·434 million dollars in 1956. Although the effects on scientific and technical man-power are likely to be long-term in character, the increased support of institutes for the supplementary training of teachers of science and mathematics and of teacher fellowships should not be slow to raise the standard of teaching and indirectly to attract more outstanding students to such subjects.

It is also proposed to expand the Foundation's other efforts to encourage more able students to consider science as a career, and to stimulate improvements in the content of science courses at all levels of the educational system. Recent annual reports of the Foundation have described what is being done in this way, but provision is now recommended of funds which will enable the Foundation to provide fellowship support for secondary school science teachers during the summer months, for graduate students who serve during the school year as teaching assistants, and for individuals who wish to extend their education so that they may become teachers of science and mathematics in high schools.

The increased appropriation to the National Science Foundation is only a part of the programme for expanding scientific education in the United States. Some 10,000 new Federal scholarships annually are recommended, reaching a total of 40,000 in the fourth year, with reasonable preference for students in science and mathematics, and with this programme greater efforts both federally and by the several States to improve selection and eliminate the waste of talent which results from leaving school prematurely, etc. Other appropriations, both federally and by the States, for the improvement and strengthening of science and mathematics teaching in the schools are proposed; for example, by provision of additional laboratory equipment or raising salaries, and increasing the supply of teachers by providing more graduate fellowships from the Department of Health, Education and Welfare for teachers, with increased Federal and State grants to institutions of higher education to enable them to expand their graduate school capacity.

Together with further support for the teaching of foreign languages and for increasing the supply of statistical data on education, the programme amounts to about 1,800 million dollars over the next four years, and it is intended to supply the increased trained man-power required in the balanced programme towards what the President described in his State of the Union message as "total peace". The elimination of waste and duplication of effort, in the Services and elsewhere, the increased co-operation in science and technology, the expanded and re-oriented defence effort, improved and more effective communication of scientific and technical knowledge, whether within the United States or between the United States and other countries, and the expanded programme of economic aid and technical assistance, on which the President laid special stress, are all dependent on trained man-power. As in Great Britain, it is not simply a matter of sufficient scientific and technical man-power to devise and execute the detailed programmes of defence, research and technical assistance; it is also a matter of the nation generally, and especially of its administrators and representatives, having sufficient understanding of what is required to afford the necessary support for programmes which will make the wisest use of available resources, and accept the sacrifices and economies demanded elsewhere.

It is, of course, the recent demonstration of Russian advances in technology that has stimulated this greater concern with the teaching of science and technology, as providing a firm basis for further advances in fields where it had been believed that leadership rested with the United States. They are also intended to remove deficiencies in the educational system of the United States which the surveys of the National Science Foundation and other bodies had revealed. It could be urged that the United States is attempting to do too much at one time, and there may be a danger that the balance of the President's programme will be upset by Congress.

Whether or not it is necessary to curtail the total effort of the United States, the balance is demonstrably sound. Wise economy is more likely to be achieved by eliminating the waste and overlapping to which the President referred, and by the wise choice of objectives in full and effective co-operation with the other members of the North Atlantic Treaty Organization. If that is to be done, the improvement of scientific and technological co-operation is all-

important. This, far more than the relative number of scientists and technologists which we can produce in Britain and in the United States compared with the U.S.S.R., is the real issue. It is quality rather than quantity that matters. Security depends not so much on numbers as on whether we improve further the quality of the scientific and technical training given in the schools, colleges and universities; on the effectiveness with which we are able to administer and organize our research and development effort both nationally and in co-operation with other NATO powers; and on the ability with which we can focus the attention of our best scientific and technological minds on the technical problems that are of critical importance in security.

For this reason again the attitude revealed in Mr. Nicholls's reply on December 10 is disturbing. This is no time for complacency on our part. Rather a keen appraisal of our whole administrative structure for liaison and communication and for the effective organization of our research effort is required, so as to ensure that here, too, there is ample provision for the rapid modification and acceleration of programmes when required so as to take prompt advantage of important discoveries or technological developments. The President's budget proposals include a contingency research of 500 million dollars for this purpose for defence alone, as well as authorization of transfer of up to 2,000 million dollars in appropriations if required. Besides provisions for increased research and development on military satellites and outer-space vehicles, on anti-missile systems and basic and applied research in various fields, the expenditure of the Atomic Energy Commission will increase from 2,300 million dollars in 1958 to 2,550 million dollars in 1959, covering both military purposes and development of the application of nuclear energy for peaceful purposes.

The mutual security programme outlined by President Eisenhower is not concerned simply with military assistance, or even with reciprocal trade, although it includes a recommendation to remove a rider in the Defence Appropriation Act which is inconsistent with the expansion of international trade and increases the cost of defence. It includes further provision for assistance to the less-developed countries from the Development Loan Fund authorized in the Mutual Security Act of 1957, and a further 164 million dollars for technical assistance in 1959, both for the United States' own programme and for that of the United Nations. As was emphasized in an all-party rally in support of the programme at Washington on February 26, these mutual security measures are an essential element in the defence of the free world. They are aimed at promoting welfare and goodwill and removing the causes of tension and misunderstanding.

Even more than in execution of the defence measures required for the Armed Services, the success of such measures depends on public understanding, and this in turn on the state of public education. The President's message to Congress shows that this is now increasingly realized in the United States, and it should stimulate a fresh sense of urgency and a non-party approach to the problems of expanding or modifying the educational system in Britain, in order to provide, not simply the greater numbers of technologists and scientists and technicians required, but also the administrators and citizens capable of taking an intelligent interest in affairs and of appreciating the scientific and technical factors which enter into defence and international relations. As Prof. E. W. R. Steacie pointed out in his challenging Purvis Memorial Lecture in Montreal last November to the Society of Chemical Industry, we have to take account of the impact of society on science. That impact can hinder the development of defence as much as that of science, and may even prove an obstacle to international understanding. Such considerations alone give fresh pertinence to the Berkener report on "Science and Foreign Relations". Although issued in 1950 and concerned primarily with the international flow of scientific and technological information, its observations and recommendations bear closely on co-operation in scientific and technological matters generally.

It needs no more, for example, than the reply already quoted to the question regarding a scientific attaché in Moscow to suggest that the Foreign Office as well as the Lord President's office would be more effective if provided with a small scientific staff at policy-level competent to apply scientific and technological judgment in the formulation of foreign policy. The Berkener report recognized that scientists and technologists need to acquire appropriate experience before they can usefully fill such offices; but that is a matter both of seeing that the educational system encourages the right outlook and qualities, and that the administrative structure is such as to provide reasonable opportunities and encouragement.

The specific recommendations of the Berkener report regarding a science office in the Department of State relate, of course, to American conditions; but they have implications for Britain which might be examined by the Advisory Council for Scientific Policy, if not at some higher level. This is equally true of those relating to overseas scientific staff. The services which such staff could render is well displayed in the report. Some of the functions, so far as Great Britain is concerned, are already carried out by the British Council, for example, in relation to the interchange of scientific staff. It seems obvious that staff of the type envisaged in this report could do quite a lot to remove obstacles to the free flow of scientific and technological information, to foster movement and interchange of scientists, technologists and others, and generally to stimulate that free exchange of ideas upon which scientific and technical advance and the security of the free world ultimately depend. They could also provide an important safeguard to the flexibility and variety of contacts which are an important feature if the organization of research and its interrelations are not to become stereotyped, to the detriment of creative work.

TECHNOLOGICAL INITIATIVE

Pilot Plants, Models, and Scale-up Methods in Chemical Engineering

By Dr. Robert Edgeworth Johnstone and Prof. Meredith W. Thring. (McGraw-Hill Series in Chemical Engineering.) Pp. xi+307. (London: McGraw-Hill Publishing Company, Ltd., 1957.) 71*s.* 6*d.*

ONE of the legacies of the war years has been a noticeable decline in technological initiative in many of Britain's basic industries, with a consequent growing dependence upon foreign sources for new plant, processes and products. While this trend may in part be attributed to the dislocation of industry resulting from the War, one cannot avoid a suspicion that, with full order-books, there is still a disinclination on the part of manufacturers to embark upon the onerous and often costly development work associated with innovations to existing practice. It is argued that both time and money are saved by allowing someone else to do the development work and thereafter buying the new process on a royalty basis.

From a long-term point of view such a policy has little to recommend it; not only is purchased 'know-how' always out of date but, in addition, British technologists are deprived of unique opportunities for acquiring that experience which is only to be obtained by pioneering work in new fields.

In Britain there are many circumstances favourable to the encouragement of initiative in industry. Our scientists are still in the van of fundamental research and discovery, we have a large and varied manufacturing potential and we have an unrivalled body of craftsmen with a long tradition of skill and resource behind them. Nor need we be too apprehensive as to the cost of development work.

Recent advances in chemical engineering science have greatly simplified the task of designing new plant, and the introduction of scientific methods of scaling-up, together with the application of statistical methods for the programming of experiments, have considerably reduced the cost of pilot-plant trials and in some instances have rendered them unnecessary. Furthermore, model theory as applied to process work has enabled the behaviour of full-sized plants to be studied systematically in the laboratory.

The significance of these new methods is perhaps not yet fully appreciated by industry, and it is for this reason that Dr. Edgeworth Johnstone and Prof. M. W. Thring's book is both timely and welcome.

In their own words, the authors have sought "to systematize and present in a usable form such quantitative methods as are available for predicting the performance of large-scale process plant from small-scale experiments". To this end they deal at some length with theoretical aspects of the subject including the principle of similarity, similarity criteria for various types of regime and scale equations. They then proceed to deal in detail with the applications of the theory to a variety of plant including heat exchangers, packed towers, chemical reactors, furnaces and kilns, ball mills and mixers. The treatment is comprehensive, quantitative and in a form which is immediately usable by the designer. A number of well-selected examples are fully worked out and serve to illustrate practical procedure.

A final chapter deals with the general theory and application of analogue models to chemical engineering problems.

Taken as a whole, the book present a well-balanced picture of the present state of knowledge of the theory and practice of scaling-up. It emphasizes the difficulties associated with mixed regimes in which both chemical and dynamic processes are involved and it gives valuable practical guidance in the design and use of pilot plants and models in the process industries.

D. M. Newitt

THE STUDY OF BACTERIAL PLANT PATHOGENS

Plant Diseases due to Bacteria

By Dr. W. J. Dowson. Second edition. Pp. xv+232+30 plates and 21 maps. (Cambridge: At the University Press, 1957.) 32*s.* 6*d.* net.

MOST plant pathologists know how to set about identifying the fungi and viruses that cause plant diseases, even if they sometimes get the wrong answer, and many have more than a nodding acquaintance with common bacterial plant diseases, but there are still too few who have learnt how to grow and study bacteria in pure culture or how to assess the significance of different morphological and cultural characters when trying to identify and classify them. This is no doubt partly due to the relative unimportance in Britain of plant diseases caused by bacteria, but there has been little or no instruction in the subject in most universities and there was no book suitable for advanced students. Indeed, such books as did exist until recently were out of date, costly, and not easy to come by.

For those interested Dowson provided the necessary guidance in his book published in 1949, and the fact that a second edition has been called for within ten years is a striking but not surprising tribute to its value, bearing in mind the narrowly specialized nature of the subject. For twenty-five years Dowson has studied bacteria and bacterial plant diseases at Cambridge and has passed his knowledge on to generations of students. He has also produced a classification of plant pathogenic bacteria which is basically sound and likely to endure. His book is a valuable one if only for the fully documented and profusely illustrated descriptions of bacterial plant diseases, which occupy rather more than half the text. Nevertheless, its primary concern is with the bacteria themselves, and in the early chapters on the classification and behaviour of bacteria, on methods of staining and studying them, and on suitable culture media, there is a wealth of information illuminated by long practical experience.

In the second edition, issued under a new name and from a different publisher, the general plan is unchanged, but the text has been revised and enlarged, and a new chapter on the preservation of bacterial cultures added. The decision of the International Committee on Bacterial Nomenclature in 1953 to invalidate the generic name *Bacterium*, without proposing an alternative, added to the difficulties in classifying the Enterobacteriaceae, which includes a number of bacteria pathogenic to plants. As a temporary measure the author has adopted the names *Erwinia* and *Pectobacterium* for the Gram-negative coliform plant pathogens, among them the familiar soft-rot organisms, now put under *P. carotovorum* (Jones) Waldee, and the crown gall bacterium, for which the new combination *Erwinia tumefaciens*

(Smith and Townsend) Dowson is proposed. New British diseases dealt with include silvering of red beet (*Corynebacterium betae* Keyworth, Howell and Dowson) and slow wilt of carnation caused by a bacterium related to, if not identical with, *Pectobacterium carotovorum* f. sp. *chrysanthemi* Dowson.

W. C. MOORE

NEUROPHYSIOLOGY

Fundamentals of Clinical Neurophysiology

By Paul O. Chatfield. Pp. xiv+392. (Springfield, Ill.: Charles C. Thomas; Oxford: Blackwell Scientific Publications, 1957.) 63*s*.

Physiology of the Nervous System

By E. Geoffrey Walsh. With chapters on Somatic Sensibility and the Applied Physiology of Pain by John Marshall. Pp. xvi+563+6 plates. (London and New York: Longmans, Green and Co., Ltd., 1957.) 50*s*.

DR. CHATFIELD'S book is an account of the physiology of the nervous system based on his first-year lectures given at Harvard. It is well balanced and admirably produced. He has something to say on all topics from peripheral nerve to the frontal cortex. Unfortunately, what he has to say is often a little perfunctory. He neither takes sides nor clearly expounds the opposing views in current controversies. He mentions the "local responses of Rushton (1937)" apparently with approval, but reproduces a curious family of hypothetical curves of the excitability changes in nerve during the passage of a constant current which were shown to be erroneous by Rushton in 1932. He mentions Lorente de Nó's views on the components of the resting potential of nerve but ignores all the work on the nerve sheath and its polarization. He also includes a good deal of old work which is not of much importance to anyone and certainly not to the elementary student. He industriously rakes the dead ashes of controversies over inhibition, and describes at length the potentials conducted electronically along the axons into the ventral roots, although their value has diminished now that we have access to the source of these potentials in the motoneurones themselves.

Any student in Britain who has the time to read a book of this length on the central nervous system will need one which is more critical, more coherent and more up to date.

Dr. Walsh's book should be called an introduction to clinical neurophysiology. He seems to be assuming that readers will already be familiar with the treatment of the central nervous system to be found in general text-books of physiology. He spends very little time on the nerve impulse, dismisses synaptology in a few pages and gets on with the mechanisms which underlie experimental psychology and clinical neurology. On the topics with which he does deal, the balance of his treatment is sometimes surprising. In the section on spinal shock in man he scarcely mentions the rate of recovery of spinal muscular and cardiovascular mechanisms, but describes inversion of the radial reflex at some length.

Nevertheless, in subjects which he treats at length, the book is very good indeed. His account of posture, the vestibular apparatus and cerebellum is certainly the best in English since Creed's edition of Camis. He gets away from the slightly garbled accounts of Magnus's work which are usually reproduced in physiological text-books by drawing on Rademaker, André-Thomas, Zador and the experimental psychologists. His illustrations from Gesell of the development of standing in children emphasize that in man posture is determined very largely by cortical activity. He dismisses Larsell's use of the classification of the cerebellum into neo-cerebellar and palaeo-cerebellar divisions, and reinterprets a wide range of clinical and experimental observations in terms of the newer knowledge of the control by the cerebellum of the sensitivity of the muscle spindle. On voluntary movement he brings together the ideas from experimental psychology which have been discussed since 1939 and gives a coherent account of them in a physiological framework. The account of the organs of special sense and their central connexions is also good, extensive and enlivened by the application to classical problems of modern views on the signalling of information. He makes a number of general points on the investigation of the central nervous system which should be marked and digested by many workers. The implications for experimental analysis of Lorente de Nó's principle of parallel pathways are set out here very clearly.

The references are extensive, well chosen, full of unfamiliar and useful guides to further reading.

All neurologists, all experimental psychologists and those neurophysiologists whose interests are not limited to the spinal cord should undoubtedly read this book.

D. WHITTERIDGE

PREHISTORIC AFRICA

The Prehistory of Africa

By Prof. H. Alimen. Translated by Alan Houghton Brodrick. Pp. xviii+438+25 plates. (London: Hutchinson and Co. (Publishers), Ltd., 1957.) 63*s*. net.

THIS is a most useful work, none the less so for the fact that one can be fairly certain that no future serious writer on prehistory will ever dare to use such a title. The area of Africa is so vast, and so much has become known of early times in the continent during the past two or three decades, that no one can hope to give the complete story or even a balanced picture of the whole. Prof. H. Alimen has done well and her book will be welcomed by students, but even while she was writing it new and important information was being unearthed.

For example, quite a lot of work has been done in West Africa between the Sahara and the Gulf of Guinea since Chapter 7 was compiled; and no account is given of the great site near the Kalambo Falls in Northern Rhodesia, where the use of wood for tool-making by Early Palæolithic man and in First Intermediate Times has been demonstrated. Father Anciaux de Faveaux, too, has brought forward a very interesting series of stone industries from the Kansenia district of the Katanga Province, Congo. They form a definite group even if their age is as yet uncertain. No mention of these finds appears. Naturally, one could cite numerous other cases where no account is given, either because there was no room or because the descriptions, usually published in local journals, have not been available to the author. However, this merely means that the specialist prehistorian in any one area must not expect that he will be given the latest information on his district; the author has obviously another end in view and that is to give, so far as it is still

possible, an overall account of the past in Africa. This has to a great extent been accomplished.

The book opens with accounts of the Maghreb, Tripolitania and Cyrenaica, Egypt, and the Sahara and its southern fringes. More information will be available on Cyrenaica when the account of Dr. Charles McBurney's digs there is fully published. In the meanwhile, Prof. Alimen's chapters are very useful. I sometimes feel that not enough has been allowed for the impassability of the great desert. During pluvial times the area could be traversed and the central African elephant found its way into the Atlas Mountains; but surely at all later times there must have been an impassable barrier which prevented north–south contacts. Thus, the evolution of the cultures to the south of this barrier has been different from that to the north, where the connexions are clearly Mediterranean. Examine, for example, the cultures north of the region where the Western Sahara goes down to the Atlantic and compare them with those lying to the south. The 'feel' is entirely different.

An account of the prehistory of Abyssinia and Somaliland follows, with a chapter on that of East Africa. Here the works of Desmond Clark on Somaliland and of Louis Leakey in Kenya have been of vital importance and are drawn upon, but Glover's discovery of an interesting rock-shelter art in the former area is not mentioned. Something has already been said about the next two regions described, West Africa and the Congo. Students will thank Prof. Alimen for explaining the maddening local names for cultures invented by Cabu that are current in the latter region. Finally, there are chapters on South Africa (including Central Africa), prehistoric man himself, the rock-shelter art, and megaliths. Prof. Alimen cleverly sits on the fence as regards the famous 'White Lady'; after all, she lives in Paris.

The work as a whole has been well worth while. Not everybody can visit those far-off regions, and a balanced account, even if necessarily imperfect in places and liable to be modified when the many problems now under discussion are finally resolved, will be very welcome to students. Miles Burkitt

MICROSCOPY TO-DAY

Modern Methods of Microscopy

Edited by A. E. J. Vickers. (A Series of Papers reprinted from *Research*.) Pp. iii+114. (London: Butterworths Scientific Publications; New York: Interscience Publishers, Inc., 1956.) 15*s*.

ALTHOUGH the microscope was invented in the seventeenth century, it was little used for scientific research until nearly 200 years later, since when it has become, as A. E. J. Vickers says in his introduction to this book, "the most important single instrument for research—it is indeed the symbol of science". Though this instrument is so widely used, the more recent developments in microscopy may not be so familiar; microscopic interferometry, the reflecting microscope, the X-ray and flying-spot microscopes are all relatively new, and will certainly play an increasing part in modern scientific research.

This book consists of a series of papers, reprinted from *Research*, which deal with many of these newer types of microscope and their use and applications. V. E. Cosslett contributes an account of the very spectacular progress made by the use of the electron microscope, and he deals with the many advances in the design of instruments and in the methods for preparing the specimens. The reflecting microscope, known since Newton's time, has only recently become important as a research tool. Reflecting objectives have several advantages, including the fact that they can be designed to work at a high numerical aperture, and that they can be made completely achromatic over a wide range of wave-lengths. Two of the papers, by K. P. Norris and E. M. F. Roe, deal with the history, development and possible applications of the reflecting microscope; there is a very good account of microspectroscopy in the ultra-violet and infra-red ranges, a technique which will undoubtedly become a very useful tool of the histochemist.

Until recently, fluorescence microscopy has also been much neglected, and, as J. King points out in his article, the pioneer work of Ellinger, Hirt and others is largely unknown. This method of microscopy is very useful in that it enables various fluorescent substances to be located in plant and animal tissues, and allows certain fluorescent dyes or fluorochromes to be used as specific stains for substances such as nucleic acids. One of the most noteworthy advances in this field was made by Coons and Kaplan, who showed that it is possible to prepare a fluorescent antibody–protein complex, which may be used to locate an antigen in tissue cells, as the site of antibody–antigen precipitate is visible when the preparation is examined with ultra-violet light.

From a biological point of view, the most important discovery in microscopy so far is considered by many people to be that of phase contrast. R. Barer's article gives a clear account of the theory of the method, and describes its advantages for the study of living cells, together with one of its more recent applications—the measurement of the solid content of cells by refractometry. The closely allied technique of interference microscopy, which allows measurements of optical path-difference to be made, is also described in detail. Most cells are virtually colourless, but they can be made to appear coloured under the interference microscope when it is used with white light, as described in the article by F. H. Smith. He explains that this is because the simultaneous presence of different wave-lengths results in a corresponding mixture of phase differences; as intensity of light is a function of phase difference, some wave-lengths are attenuated with respect to others, and colour contrast is thereby obtained, facilitating morphological studies of the cell and its inclusions.

The polarizing microscope is also considered, especially with regard to its usefulness in identifying crystals and in throwing light on the fine structure of biological materials.

Methods of microscopy which may still be said to be in the experimental stage are the flying spot and X-ray microscopes. The article by D. Causley and J. Z. Young gives a clear account of the former, explaining the method and outlining its use in the counting of red blood cells, nerve cells and other biological and metallurgical materials, while W. C. Nixon explains the development and uses of reflexion, contact and projection X-ray microscopy.

The book is very well produced and illustrated, and will, I feel, prove very valuable to research workers and any others who are interested in some of the newer approaches to the use of the microscope; a very valuable feature is the provision of references at the end of each chapter. S. Bradbury

Atomic Energy and Agriculture

Edited by C. L. Comar. (A Symposium presented on December 27–29, 1955, at the Atlanta Meeting of the American Association for the Advancement of Science and Co-sponsored by the Oak Ridge Institute of Studies, under contract with the United States Atomic Energy Commission.) (Publication No. 49.) Pp. x+450. (Washington, D.C.: American Association for the Advancement of Science; London: Bailey Bros. and Swinfen, Ltd., 1957.) 86*s*.

OF twenty-two specialist contributions to this book, eight deal with various aspects of the use of ionizing radiations for such purposes as pest destruction, sterilization and plant breeding. These are of great interest and carefully assess the advantages and disadvantages of the techniques. The remaining fourteen papers are on assorted biochemical topics in which radioactive tracers have been used as a research tool. It is remarkable that after more than a decade of the use of isotopes in biochemical research, it is still thought worth while to combine in a single volume a number of topics which have in common only the use of this single research method.

The papers themselves are nevertheless of value, written as they are by experts in the various fields. As one would expect, all the contributors are American, but most of them have international reputations. Thus, to name but a few, we find C. L. Comar, who has not only edited the volume but also, with R. H. Wasserman, has contributed a paper on macronutrient metabolism. Lactation and hormones are dealt with by J. C. Shaw and S. Lakshmanan, and photosynthesis by N. E. Tolbert. If anything, the emphasis of the symposium as a whole is in favour of work on plants and soil rather than on animals, but most agricultural topics of importance are covered. Papers cited in the references are listed by author and date, and in about half of them the title is included. The book is well produced and printed and will be found useful by most biological research workers.

R. F. GLASCOCK

Annals of the International Geophysical Year

Vol. 4, Parts 1, 2, and 3. Pp. 202. Vol. 4, Parts 4, 5, 6, and 7. Pp. 203–393. Vol. 5, Parts 1, 2, and 3. Pp. 244. Subscription per volume: 120*s*.; 17 dollars. (London and New York: Pergamon Press, 1957.)

VOLUME 4 of the Annals of the International Geophysical Year contains instructions by leading authorities for the observations of radioactivity in the atmosphere and oceans, aurora, airglow, noctilucent clouds, latitude and longitude, geomagnetism, seismology and cosmic rays to be made during the International Geophysical Year. It includes descriptions of instruments, practical hints on observing, methods of reducing the observations, and notes on the specific problems on which it is hoped these observations will throw light. The articles on aurora and airglow go rather beyond this and are interesting short text-books in themselves.

Volume 5 contains instructions for the observations of the distribution of ozone in the atmosphere for auroral photography with the special all-sky camera developed by W. Stoffregen at Upsala Ionospheric Observatory, and the Manual of Communication for radio transmissions in the Antarctic during the Geophysical Year. Part I on ozone gives full instructions for the use of the Dobson ozone spectrophotometer and the calculation from its readings of the vertical distribution of ozone. The volumes should be useful as descriptions of techniques long after the International Geophysical Year has come to an end. The production by the Pergamon Press, especially the reproductions of the autographic records, complicated circuit diagrams, and instrument drawings, is excellent.

G. A. BULL

The Exact Sciences in Antiquity

By O. Neugebauer. Second edition. Pp. xvi+240+14 plates. (Providence, R.I.: Brown University Press, 1957.) 6 dollars.

DURING the six years that have elapsed since this standard work first appeared, numerous further contributions have been made (not least by its distinguished author) to our understanding of ancient Eastern mathematics and astronomy and of their relationship to Hellenistic science. The preparation of this second edition has afforded Dr. Neugebauer an opportunity for adjusting the text and revising the closely printed pages of notes and references in the light of the most recent revelations. Of particular interest is the novel explanation of how the Egyptians' choice of thirty-six 'decanal' constellations (arising from the decimal structure of their civil calendar) led on directly to the familiar division of the night, and eventually of the day, into twelve hours each. However, the principal additions to the book are two long appendixes; the first deals with the geometrical techniques of the Ptolemaic planetary theory and with the modifications introduced by Copernicus; the second illustrates how some of the developments of Greek mathematics originated from the practical needs of astronomy and geodesy. This book (accurately reprinted in Denmark) has become an indispensable tool for students of the obscure origins of our mathematical heritage; they will be gratified to find it re-sharpened for their use.

A. ARMITAGE

Inorganic Chemistry

A Textbook for Advanced Students. By Dr. E. de Barry Barnett and Dr. C. L. Wilson. Second edition. Pp. xvi+588. (London and New York: Longmans, Green and Co., Ltd., 1957.) 35*s*. net.

IN the preparation of a new edition of this useful book many of the sections have been rewritten and brought up to date, and the size has been somewhat increased. Since some references to literature are given, the information in the original sources can be turned up if required. The book is intended for advanced students, so that many parts of the subject dealt with in elementary works are omitted. This makes it less suitable as a book of reference. The treatment is sound and accurate and the book is interesting to read. Occasionally, the authors refer in rather severe terms to current opinions and sometimes advance theories of their own. In one case at least, namely, on the action of nitric acid on metals, their theory is certainly incorrect; as a general rule it is better not to introduce such matter into a book intended for students. The book will be found very useful in preparation for university degrees or comparable qualifications and will certainly be helpful to teachers of advanced pupils in schools. It is very well printed on a large page. Although the authors have added a couple of pages of 'stop-press' information, the text is already out of date in a few cases, for example, on the hydrides of boron.

J. R. PARTINGTON

MAX PLANCK (1858–1947)

By Prof. H. T. FLINT

IT will come to many as a surprise that this year is the centenary of the birth of Max Planck. He was born on April 23, 1858, and died on October 4, 1947, so that he reached his ninetieth year. Until the last few years of his life he preserved his physical and mental activity, and it was difficult to think of him as a man of great age. Moreover, his work is ever bubbling with vitality and the latest phase of it, although born more than thirty years ago, is still described as new.

Accounts of him personally and of the details of his life are fresh in the minds of those who knew him, and of many more who read about him on the occasion of his death. The details and the importance of his work are known universally. It is impossible to avoid repetition of much that was written ten years ago, but it seems appropriate on this occasion to recall some of the principal contributions he made during his long and fruitful life and to emphasize their influence on scientific knowledge and thought.

For Planck, the search for the laws of Nature and the attempt to understand the character of which they are the expression was a vocation. He wrote in his autobiography that he was convinced that the universe represented something absolute and independent of ourselves, about which it was possible to draw conclusions by the process of pure thought. He regarded the search for natural laws as the most worth-while of the scientific problems that life could offer.

As a schoolboy he was fascinated by the principle of the conservation of energy, by reason of its character as something independent of man. In the University of Munich he attended lectures by Helmholtz and Kirchhoff, but appears to have been disappointed by both. At this time of something like frustration, he began to read the work of Clausius, being attracted to it because it was related to the principle of energy. Here he found what he wanted and devoted himself with enthusiasm to the formulation of the second law of thermodynamics.

Before Clausius, it appears to have been generally held that the passage of heat from a body at higher temperature to one at lower temperature was a process exactly comparable with the falling of a weight from a higher to a lower level. Planck was impressed by Clausius's recognition of a sharp distinction between the two laws and by his deduction of the second law from the principle that heat does not of itself pass from a colder to a hotter body. But he found difficulty in this hypothesis because it needed a particular elucidation, for what is meant is that it is in no way possible to get heat from a colder to a warmer body without leaving a change somewhere by way of compensation. He was convinced that it was possible and desirable to discover a formulation which came more closely to the root of the matter. He thus arrived at the statement that: the process of heat conduction cannot in any way be completely reversible. This statement requires a definition of reversibility and irreversibility. He then gave his definition of an irreversible process as one which cannot be cancelled—that is to say, as one in which the original situation cannot be restored. He was insistent in opposing the insufficient statement that such a process is one which cannot run backward, for it is possible that although the process cannot run backward the original situation may in some way be restored. His study of these questions led him to the conclusion that whether a process is reversible or not depends only on the nature of the initial and final states. In an irreversible process Nature has a preference for the final state, and Planck regarded the entropy of Clausius as the measure of this preference. The quality of this early example of Planck's keen insight and critical power can be gauged by the fact that the point is not apparently completely grasped by some writers and teachers even to-day.

These ideas formed the subject of Planck's thesis for the doctorate in 1879, when he was twenty-one years old. His insight and critical power stand out still more clearly from the fact that his teachers failed to grasp his points. He writes that Helmholtz paid no attention to his work and that Kirchhoff brushed it aside, saying that the notion of entropy was only to be defined and measured by means of a reversible process and could not be applied to irreversible ones. Planck expresses the opinion that had his work in the seminar not been known and approved by his teachers, the thesis would not have been accepted.

He was, however, convinced of the importance and correctness of his conclusions, and regarded entropy and energy as the two most important properties of a physical system. He went on to apply his ideas to the study of physical and chemical states of equilibrium, being forestalled to some extent by Willard Gibbs, although unaware of this at the time. But Planck had made his point, and his influence on the study, teaching and application of thermodynamics is of the highest order. His book "Thermodynamics" is the greatest and most fundamental of all available treatises on this subject.

The recognition of Planck's work on the significance of entropy came as a result of Boltzmann's molecular theory. It is well known that a certain quantity H is in this theory associated with the state of a gas, and that it diminishes with the time. If the entropy is associated with the negative value of H, the principle of increase of entropy is established for processes in gases.

Planck was much influenced by Boltzmann's work and had a high regard for it. Boltzmann, on the other hand, showed a dislike for Planck's point of view. The differences between them lay in the fact that Planck's principle was a universal law admitting no exception and was indifferent to the foundations on which Boltzmann's work rested. The latter was a theory of probability admitting exceptions. It is, however, certain that Planck's admiration for the ideas of Boltzmann made him feel that he was almost one of his pupils, scarcely distinguishing between what he had learned and what he had contributed to this statistical, thermodynamical theory. A study of Planck's work in this field shows that here also his insight and critical power led him to formulate the basis of the statistical theory as it is now generally known. In his book "Heat Radiation", Planck devotes a chapter to the relation between

entropy and probability. This must be one of the best known and most fundamental of all works on the statistical theories of physics. In the course of it he writes that the logarithmic connexion between entropy and probability was discovered by Boltzmann, and he gives a reference to a passage in Boltzmann's "Lectures on the Theory of a Gas". But it seems that the relation, $S = k \log W$, to which he refers, is his own interpretation of Boltzmann's discussion, for there is no mention of it in the passage. Sommerfeld has recorded that many years ago he had come to the conclusion that this formula was not included in Boltzmann's work. It is surprising to find that the constant k was not introduced by Boltzmann, who did not work in terms of actual molecules but with gram molecules. In the notices which appeared in *Nature* and in the *Proceedings of the Royal Society* in 1906, on the occasion of Boltzmann's death, written by G. H. Bryan, there is no mention of the constant k, nor of this formula, among his contributions to physics.

One must agree with a remark of von Laue, made at the time of Planck's death, that to write of his greatest work and of its influence upon scientific thought and progress is to run the risk of being trivial or even ludicrous. A popular German encyclopædia writes under his name: "The founder of the quantum theory". No more is needed; no one could wish for a greater tribute. His youthful wish to discover the laws of Nature from the study of absolute phenomena made him recognize in black-body radiation the ideal field for his inquiry, and again his genius, his insight and clear thinking took him to his goal, this time to a height exceeding his greatest ambition. There is no doubt that he recognized the greatness of his discovery, as there is no doubt that he sometimes gave the impression that he had been awed by it.

Planck's discovery of the quantum of action and Einstein's discovery of the theory of relativity have often been compared, not on account of their physical content, but in respect of their originality and relative importance. But discussion on this question is of little significance. In different ways both have had a profound influence on scientific thought and, by an analogy, on other fields of knowledge. Their influence on experimental physics has been almost equally profound, and the consequences upon daily life which will flow from them seem at this stage to show no bounds. The theory of relativity is like a crown of the classical theory. The approach to it and the notation by which it is described are essentially classical, and Einstein has himself written of Lorentz's discovery of the equations of transformation that, once they were known, the special theory of relativity simply had to follow.

It is rare, in any form of progress or in any discovery, that success can be with truth attributed to one man. This is especially true in science, where suggestion and counter-suggestion, frustration and disappointment, failure and renewed effort all make final success possible. But of Planck it can be said, and it is universally held, that the foundation of the quantum theory is his alone. He lived long enough to see how universally applicable was his principle of quantization.

That harmony and unity exist in the physical world throughout its whole extent has for a long time been a belief that has inspired physical research. It was certainly held by Planck and Einstein. If it is so, the quantum theory is the foundation of all physical theory, and to all that has been done which makes this evident will be added one day the solution of the difficult problem, occupying many at the present time, of including the theory of gravitation in this doctrine.

Planck's influence upon his contemporaries did not end with his scientific achievements. He was regarded by his own countrymen in the later years of his life with affection and almost with reverence, and part of the message of appreciation sent by the Royal Society on the occasion of his death may well conclude any tribute paid to him: "As a man he commanded the approbation of our hearts, of character, modest, kindly, blameless, through sorrows courageous and always a man of integrity. His name will live as long as the study of science continues".

RECENT DISCOVERIES AT OLDUVAI GORGE, TANGANYIKA

By Dr. L. S. B. LEAKEY
Coryndon Museum, Nairobi

DURING the past few years excavations have been continued at Olduvai Gorge, Tanganyika Territory, with the aid of grants from the Boise Fund for recurrent expenditure, and from the Wenner-Gren Foundation and the Wilkie Fund for capital costs. The work has been carried out by the writer and Mrs. Leakey, and in 1955, Mrs. Brown. In 1957 Miss Trace and Miss Goodall assisted.

Work has, in the main, been concentrated upon two sites: *BK* II at the lowest level of Bed II Olduvai, where it rests unconformably upon the eroded top of Bed I, and at *SHK* II at a level about 10 ft. above the base of Bed II.

The culture of the *BK* II site is African Chellean stage 1, and that at *SHK* II is African Chellean stage 2—as defined in the monograph on Olduvai Gorge published in 1951. At each of these two sites, living-floors of Chellean man have been found, with big accumulations of stone tools, waste flakes and the fossilized remains of the animals upon which Chellean man lived.

A point in the work has now been reached when a summary of the more important results so far achieved can be given.

The Chellean I Living Site at *BK* II

The most significant facts that emerge from the study of the stone artefacts from this level are the following:

(*a*) Although the people who lived at this time had begun to make simple hand-axes, the proportion of hand-axes made was infinitesimal.

(*b*) The vast majority of the tools used were pebble tools of the Oldowan type, roughly made stone balls (such as were later used for bolas stones), a variety of

rough flake tools, and hundreds of flakes which were simply utilized in the form in which they broke away from the cores.

The following indicate the position:

9,623 specimens were excavated consisting of: simple hand-axes, 22; pebble choppers, 575; stone balls, 55; rough flake tools, 218; utilized flakes, 460; hammerstones, 58; unclassified, 299; natural stones, 1,146; waste flakes, 6,790.

The site, as seen from these, contained very large numbers of natural pebbles and lumps of rock which had been brought there by human agency, but which show no signs whatever of being utilized, or worked, in any way, by man. The significance of this is still not clear.

Among other objects found in the living-floor were two lumps of red ochre which, clearly, were brought to the site by man, thus suggesting that, even in Chellean 1 times, man was interested in colouring matter.

The fossil fauna which littered the whole of the living site includes the following genera and species, many of which are represented by excellent specimens in large numbers: *Simopithecus* sp., *Cereopithecus* sp., *Papio* sp., *Felis* sp., *Hyaena* sp., *Rhinoceros* sp., *Serengetitherium* sp., *Potomochoerus majus*, *Mesochoerus olduvaiensis*, *Phacochoerus altidens robustus*, *Orthostonyx brachyops*, *Afrochoerus nicoli*, *Notochoerus hopwoodi*, *Tapinochoerus meadowsi*, *Notochoerus compactus*, *Palaeoloxodon antiquus*, *Archidiskodon* sp., *Pelorovis olduvaiensis*, *Bularchus arok*, *Hippopotamus gorgops*, *Hippopotamus* sp. (a small species), *Giraffa capensis*, *G. gracillis*, *Sivatherium olduvaiensis*, *Equus olduvaiensis*, *Equus* sp. (smaller), *E.* c.f. *burchelli*, *E.* c.f. *grevyi*, *Hipparion* sp., *Stylohipparion* sp., *Eurygnathohippus* sp. (= *Metaschizatherium* ?).

There are also the remains of numerous species of antelope and gazelle, which have not yet been sorted out and classified, a number of rodents, many bird bones and some reptilian remains including crocodile.

In addition to the above fossils, which are represented in most cases by large numbers of specimens, there were found, in direct association with each other, in 1955, two hominid teeth (Fig. 1). It was hoped that this important discovery, made at the close of the 1955 season, was the precursor of further finds

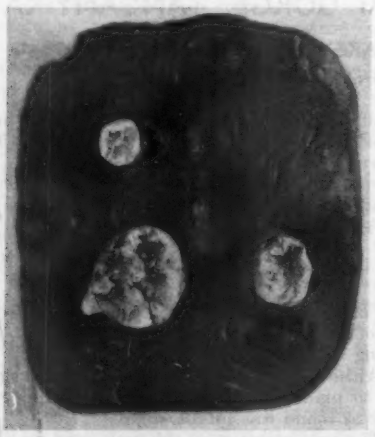

Fig. 1. The two fossil hominid teeth, lower milk molar and lower canine (both on the left), with a corresponding modern lower milk molar on the right. Natural size

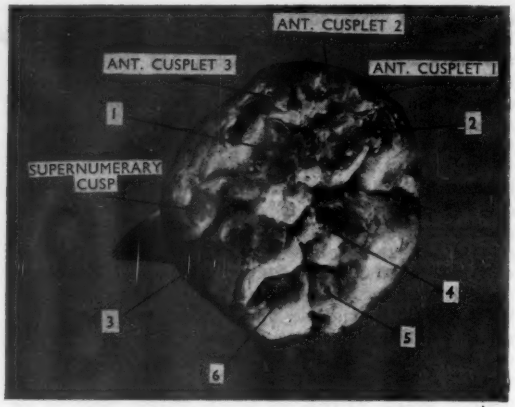

Fig. 2. Enlargement of the one fossil tooth to show the cusp pattern of the molar

of hominid material, but the hope has not been fulfilled and, therefore, a preliminary description of these teeth is given here.

The molar tooth (Fig. 2) is so unusual in its cusp pattern, as well as so large, that there has been a considerable amount of disagreement, both among dental specialists and human anatomists who have seen it, as to which tooth in the series it represents. After very lengthy study and comparison, I am satisfied that it is a left lower second deciduous molar.

It is very large, having a length of 15 mm. and a maximum width of 14 mm., giving an index of 93·3. The width is exaggerated by the presence of an unusual supernumerary cusp situated on the buccal side between cusps 1 and 3 (using the Gregory and Hellman system, which is used throughout this article). This has caused a swelling of the crown near the base which has led to this unusual maximum width.

The evidence that the tooth is a deciduous one lies (*a*) in the nature of the roots, which have the characteristic divergence to accommodate the crown of the growing 4th permanent premolar below, (*b*) the characteristic constriction of the neck, (*c*) the nature of the roots themselves, and (*d*) the association with a part-worn lower deciduous canine.

The tooth had only very recently come into the full occlusal position when the individual died, as is shown by the fact that the wear on the cusps of the crown is insignificant. There is a clear contact facet anteriorly and none whatever posteriorly, and the combination of these two factors also points to a recently errupted second deciduous molar, the owner of which died before the first permanent molar had come into position behind it, and before there had been time for more than a very little wear of the surface of the crown. It is thus probable that this tooth represents an individual of an age comparable to 3–5 years old in modern man.

The cusp pattern is the most complex I have ever seen, or heard of, in a deciduous molar. The specimen clearly exhibits cusps 1, 3 and 5 on the buccal aspect, and 2, 4 and 6 on the lingual aspect. These six primary cusps are augmented by numerous other cuspules. First, the rim of the tooth, bordering the anterior fovia, is beaded in such a way as to present three subsidiary cuspules, of which the largest is on the buccal side, just in front of 1. Secondly, there is a

very big supernumerary cusp on the buccal side adjacent to the valley between 1 and 3. It is, as we have seen, the presence of this supernumerary cusp which has caused the swelling of the whole crown in this region, thus giving an unusual crown-width, relative to length. Thirdly, the low ridge between cusp 1 and cusp 4 and separating cusps 2 and 3 is almost in the form of a distinct cusplet. A faint trace of a cingulum can be seen anteriorly between 1 and the large anterior subsidiary cusplet on the buccal side, as well as between cusps 2 and 4 on the lingual side.

The arrangement of the main cusps and their contacts with each other are diametrically opposite to the so-called 'dryopithecus pattern' in which, in lower molars (both the second deciduous and the permanent teeth), the posterior buccal main cusp (3) is in direct contact with the anterior lingual main cusp (2), while the anterior buccal main cusp (1) and the posterior main lingual cusp (4) are separated by a ridge.

In the specimen from Olduvai we have, instead, a direct contact between the anterior main buccal cusp (1) and the posterior main lingual cusp (4), and it is this fact which has caused some of those who have examined the tooth to suggest that the specimen is a right deciduous second molar—not a left—since such an identification would give it the normal so-called 'dryopithecus pattern' which is sometimes seen in hominid molars.

The arrangement of the cusps 1, 3 and 5 is slightly curving, with 2, 4 and 6 in an almost straight line, which makes it quite clear, however, that we are dealing with a left and not a right tooth, and the root structure also confirms this. There are also those who maintain that we are dealing with an upper permanent molar of australopithecine type.

In many modern lower molar teeth the arrangement of the principal cusps is reduced to what is called the 'plus pattern', while the more primitive 'dryopithecus pattern' also occurs sometimes in both permanent and deciduous lower molars.

The question therefore arises as to whether the form of the main cusp contacts seen in the tooth from Olduvai, which is the exact opposite to that found in the 'dryopithecus pattern', ever occurs in man or in other hominids, or in hominoids. From a study of the available literature it is clear that this pattern, which is the reverse of that seen in 'dryopithecus', is found in some lower molars of Australian aborigines and also in the 2nd right molar of the Heidelberg jaw*, as well as in one or two, but by no means all, lower molars of *Sinanthropus*. This pattern is also found in some African lower molars (Fig. 3). So far as I am aware, from the literature I have studied, the arrangement of the cusps of lower permanent and deciduous molars in the *Australopithecus* genus is always either of the 'dryopithecus' or something approaching the 'plus pattern', so that the tooth from Olduvai differs fundamentally from australopithecine teeth and has affinities with the extreme opposite pattern which is seen in some Australian aborigines and other modern human teeth, and in some types of fossil man. It should be noted here that in 1926, Gregory and Hellman, discussing the origin of man, wrote, "In man, as the Dryopithecus pattern is lost through modification of several parts, the hypoconid-metaconid (3–2) contact is replaced by the opposite contact (1–4)".

* See, for example, Gregory and Hellman, 1939, "The South African Fossil Ape Men and the Origin of the Human Dentition". In this paper the tooth figured as the third lower molar of Heidelberg is almost certainly the second right lower molar.

Fig. 3. View of a mandible of a modern East African native to illustrate the 1–4 cusp contact, which is also seen in the fossil tooth

In studying Australopithecine teeth, Robinson and others have laid considerable stress on the diagnostic value of the grooves separating the cusps on the buccal aspect of lower molar teeth. It has been suggested that the australopithecines differ from the true hominids in this respect, and that in true hominids the grooves extend much farther down the crown than is ever seen in australopithecines. In this respect the deciduous molar from Olduvai would seem to approximate more to the australopithecines.

In view of the association of this tooth with a Chellean stage of culture, and the fact that *Atlanthropus* mandibles have been found with an Acheulean stage of culture in North Africa, a brief reference to the tooth pattern of the molars of *Atlanthropus* must be made.

Unfortunately, the photographs of the dentition on the three mandibles of *Atlanthropus* available do not enable me to determine the nature of the cusp contacts in the molars, so that it is not possible for me to say whether any of the lower molars exhibit a cusp contact pattern which is the exact opposite of the 'dryopithecus pattern', such as we have seen to occur in some modern hominid lower molars. One assumed that they do not, or it would have been stressed.

The roots are damaged; but it is quite clear that the posterior root was bifurcated, a condition which occurs occasionally in modern human deciduous molars, and is reminiscent of the anthropoids and some fossil human forms.

The deciduous left canine tooth (Fig. 1, top) has a length of 7 mm. and a width of 6·1 mm., thus corresponding closely in size with deciduous lower canine teeth of *Sinanthropus*, although the corre-

a *b*

Fig. 4, *a* and *b*. Two views of the flake tool made from hippopotamus tusk and afterwards fossilized, from the Chellean 2 living site (much reduced)

sponding deciduous 2nd lower molar from Olduvai is so much larger. In other words, although the tooth is a large deciduous canine by present-day standards, it is small in relation to the associated 2nd lower milk molar. In this respect there is, therefore, a similarity with the position found in the australopithecines. The crown of this tooth is worn obliquely from the buccal towards the lingual side.

In this preliminary note nothing further need be said about the canine tooth, save that the association of this part-worn deciduous canine with the other tooth substantiates the view that the latter is a 2nd deciduous lower molar.

It is tempting to try to analyse the affinities of the hominid represented by these two teeth from Olduvai which were found in association with a Chellean culture. Should they be regarded (as has been suggested to me verbally and in letters) as evidence of the presence at Olduvai of an australopithecine of even greater size than *Paranthropus crassidens*? After all, a maxilla fragment, which some authors have suggested represents an African form of *Meganthropus*, was found in the Vogel Flus area only 50 miles south of Olduvai by Kohl Larsen, and Robinson considers that specimen to be indistinguishable from *Australopithecus*. The cusp pattern of the Olduvai lower milk molar, however, is so diametrically different from any known australopithecine lower milk molar that this correlation appears to be ruled out. The affinities appear to be rather with teeth in the Heidelberg jaw as well as with one or two teeth in the *Sinanthropus* group. We are, therefore, possibly dealing with a very large true hominid which is not of australopithecine type. The teeth, in fact, suggest that we are dealing with a human.

It is quite impossible, at present, to say whether these two teeth represent the makers of the Chellean 1 stage of culture at Olduvai, or only the remains of some creature which formed part of their food. The only thing that is certain is the direct association of the Chellean culture and the two teeth.

The recently announced discovery of advanced pebble tools of Oldowan and Chellean 1 type in a breccia at Sterkfontein in South Africa, which has also yielded a few teeth of *Australopithecus*, is rightly treated by Robinson and Mason, not as proving that *Australopithecus* made the culture, but that these "near men" were contemporary with a type of early man who made these stone tools and that the australopithecines were probably among the victims which he killed and ate.

Robinson has, moreover, described what he terms a euhominid by the name of *Teleanthropus* which was contemporary with the australopithecines in South Africa, and the teeth from Olduvai may well represent a similar early human. It is not yet possible, however, to say whether it was a human of the *Teleanthropus*, *Atlanthropus* or even of *Homo kanamensis* type, or possibly some form of man not hitherto described. We must hope that future work will yield more complete remains.

The *SHK* II Site of Chellean Stage 2

The preliminary study of the material from the site shows that some progress had been achieved in the technique of hand-axe making, but that, nevertheless, pebble choppers were still the dominant tool

Fig. 5. The gigantic upper tusk of *Afrochoerus nicoli* compared with a large corresponding tusk of a modern wart hog

Fig. 6. A fossil tusk of the giant extinct bush pig, *Potomochoerus majus*, with a corresponding tusk of a modern bush pig

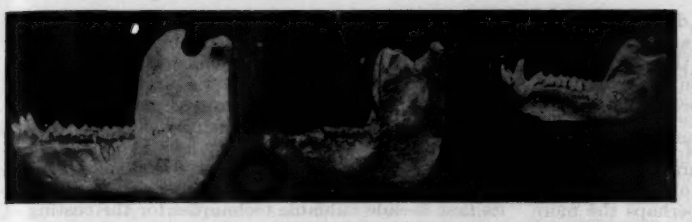

Fig. 7. The lower jaw of a female extinct giant baboon compared with the lower jaw of a male gorilla on the left and a male modern baboon on the right

Fig. 8. The anterior part of the mandibles of two specimens of *Eurygnathohippus* compared with a cast of the fossil of the type specimen from South Africa

type, so far as numbers are concerned. A preliminary sorting of the material reveals the following proportions: hand-axes, 142; pebble choppers, 792; stone balls, 46; flake tools, 251; utilized flakes, 482; hammer stones, 15; anvils, 16; unclassified, 621.

In addition, there were 1,269 natural pebbles and lumps of stone and 3,257 waste flakes showing no usage, making a total of 6,891 specimens.

The fauna differs in no significant way from that of the slightly earlier *BK* II site, but *Sivatherium* material is definitely more scarce, while there are a few broken pieces of tooth of *Dinotherium bozasi*. A detailed list will be issued at a later date.

The most outstanding find in this Chellean 2 living site is that of a fossilized flake tool made from hippopotamus ivory (Fig. 4, *a* and *b*). This large flake of ivory shows a most marked and typical bulb of percussion, and the flake scar cuts right across the natural grain of the ivory. On the upper face the natural enamel of the tusk is preserved. There is clear evidence also of secondary trimming at the end opposite the butt. The tool was made from an upper canine of *H. gorgops*, and it constitutes the first record of a tool made from ivory, in any stage of the Hand-axe culture, so far as I am aware.

The fossil fauna found during the recent work at Olduvai includes a few specimens which are worthy of special mention here. Of outstanding importance are: (1) a tusk of the giant pig *Afrochoerus nicoli* which measures 785 mm. on the curve (Fig. 5); (2) a tusk of *Potomochoerus majus* which measures 320 mm. on the curve (see Fig. 6); (3) a lower jaw of a species of a gigantic baboon, possibly a new genus, which will be the subject of a special note in the near future (Fig. 7); (4) many specimens of the fossil which Van Hoepen called *Eurygnathohippus*, which seem to suggest that this represents a large *Metaschizatherium* (Fig. 8).

OBITUARIES

Dr. J. C. Willis, F.R.S.

Dr. J. C. Willis, the veteran botanist, who died at Montreux on March 21 at the age of ninety, was the son of an American father and a Scottish mother. He was born at Birkenhead on February 20, 1868, and was educated at Liverpool and Cambridge. For two years after graduation he served as an assistant in the Botanical Department of the University of Glasgow, but at the age of twenty-eight he was appointed director of the Royal Botanic Gardens in Ceylon, a position that he occupied with distinction for fifteen years, afterwards becoming director of the Botanical Garden at Rio de Janeiro (1912–15).

During his tenure of the directorship of the Gardens in Ceylon, Willis did a great deal to organize and stimulate interest in tropical agriculture, not least during his editorship of the *Tropical Agriculturist* and the *Empire Cotton-growing Review*. Willis was a forceful personality who will be chiefly remembered in connexion with three fields of activity. When at Ceylon he wrote his "Manual and Dictionary of the Flowering Plants and Ferns" which was based mainly upon Engler's "Die Naturlichen Pflanzenfamilien"; but in its earlier presentation about one-quarter of the text was devoted to principles of taxonomy, morphology and systems of classification that filled a real gap and for its period was quite excellent. This valuable reference work, now in its eighth edition, he handed over, a few years before his death, to the Bentham Moxham Trustees, which will ensure its continued usefulness and adequate revision.

The Ceylon flora is, like that of many other oceanic islands, especially rich in endemic species, the distribution of which attracted the attention of Willis, and from this developed his statistical analysis of types of distribution and the formulation of his 'Age and Area' hypothesis. If the main theme is now regarded as having only a very limited application, it served not merely as a great stimulus to ascertaining

the relevant features of geographical distribution, but also focused attention on such facts as that endemics might be either ancient or modern, that rare species are far more numerous than common ones, and that monotypic genera are far more numerous than genera containing many species.

Willis believed that the statistical data, on which he based his hypothesis, belied natural selection and that evolution was merely a process of differentiation and a function of time. This was perhaps the more surprising since his most important contribution to descriptive botany was his monograph of the remarkable group of flowering plants known as the Podostemaceae. These grow only on the surface of rocks in rushing water and exhibit a remarkably varied and complex vegetative morphology with numerous features that, in the phraseology of that time, would be termed 'adaptations'. His contributions to science were recognized by his election to the Royal Society in 1919, and his distinction in the domain of tropical agriculture was marked by Harvard University conferring upon him an honorary doctorate when ten years earlier he had delivered lectures there on that subject.

E. J. Salisbury

Dr. J. A. Venn, C.M.G.

Many will have noted with regret the death on March 15 of John Archibald Venn, president of Queens' College, Cambridge, at the age of seventy-four. His father had been a Fellow of Gonville and Caius College, his grandfather and his great-great-grandfather had been Fellows of Queens' College, and his death ends a distinguished family connexion with the academic life of Cambridge which lasted for six generations.

John Venn was born in 1883. From school at Eastbourne College he went up to Trinity College, Cambridge, where he studied history. After taking his degree in 1905, his interests led him to economics and the history of agriculture. These studies were interrupted by the First World War, in which he served as a captain in the Cambridgeshire Regiment for two years before being called to the Department of Food Production as statistician. In 1921 he returned to Cambridge as Gilbey lecturer in the history and economics of agriculture, and he was also for some years an advisory officer of the Ministry of Agriculture.

In 1924 he became a member of Queens' College, with which his forebears had for so long been associated, and was elected a Fellow in 1927. Then, in 1932 when he was on leave in the Far East, came a cable from the governing body inviting him to become president of the College. His tenure of that office has been a most notable one. Under his wise and vigorous leadership, the size of the College has almost doubled—in accommodation, in the number of Fellows and in the number of undergraduates. In the President's Lodge he and Mrs. Venn (in 1906 he married the daughter of the late Sir William Ridgeway) kept open house and had always the warmest of welcome for all members of the College, past or present, who called there—and there were very many who did so.

In the affairs of the University of Cambridge Venn took a leading part. He was senior proctor in 1930–31, served on the Council of the Senate from 1934 until 1943, and was vice-chancellor during the difficult war years 1941–43. Local government also claimed his attention; he was a magistrate and a member of the Town Council from 1934 until his death; he was chairman of the county Agricultural Wages Board, and a conservator of the River Cam. The Colonial Office sought his advice on many matters, notably in connexion with the sugar industry of British Guiana.

Under his direction the Farm Economics Branch of the University School of Agriculture developed in its first decade valuable techniques for the costing of typical farms, both generally, to reveal changing financial fortunes over time, and also in respect of specific problems such as sugar beet. Venn's work was always soundly based on his broad historical knowledge, as was shown by his review of the Agricultural Tribunal's Report in his book, "The Foundations of Agricultural Economics" (1924, revised 1933) and in his presidential address to the meeting of the Agricultural Economics Society, which was held in Queens' College in 1933. A regular attender of the meetings of the British Association, he served on the council during 1934–39 and was president of Section M (Agriculture) in 1935.

Although agricultural economics was the subject which he taught in the University, he was primarily a historian and an antiquary. During 1933–35 he was president of the Cambridge Antiquarian Society. He and his father set themselves the unimaginable task of preparing a complete biographical register of all the men who had matriculated at the University up to the year 1900. The "Alumni Cantabrigienses" is a work of six volumes, printed in very small type; this work, and his contribution to agricultural economics, were recognized by the University with the award of the degree of doctor of letters.

That he was able to combine this time-consuming investigation with all the administrative duties which fell upon him as head of a college is a measure of his astonishing capacity for work. He gave meticulous attention to detail, yet this never for one moment obscured his vision of the wider issues. With his incisive grasp of affairs went a youthfulness, both of mind and of body, which defied the years until mortal illness laid its hand upon him. It might seem that a life so full of serious activities could have afforded no time at all for relaxation. But it was far otherwise. In his younger days he was an enthusiastic tennis player, he invented a machine for bowling a cricket ball of any required pitch or break, he was a pioneer of motoring and a keen bird-watcher. There is no doubt, however, that from mid-life onwards his interests centred more and more upon the affairs of the College which he loved and served so well.

All these varied pursuits and his recollections of events associated with them made him an entertaining companion. One will remember best the evenings in College after dinner, and the occasions when some passing remark in the general conversation would provoke the comment that it was not always so; and then from his inexhaustible knowledge of the history of the University, intimately illuminated by the diaries of the Venn family, the company would be delighted by a few revealing glimpses of the—often shocking—past. This deep understanding and affection for the past, combined as it was with a frank recognition of the need for change, made John Venn a unique personality whose loss to Cambridge will be sadly felt.

J. A. Ramsay

Dr. B. M. Cwilong

Dr. B. M. Cwilong, who died in the Middlesex Hospital, London, on January 4, was born in Russia of Polish parents, his father being a judge. He took his M.Sc. degree at the University of Warsaw. He was working in the Polish Meteorological Service when war broke out in 1939 and was called up, and when Poland was over-run he went with the Polish Army to Italy, to France and finally to England. Here he was sent to work at the Clarendon Laboratory, Oxford, and assisted in developing instruments for measuring the very low humidities of the upper atmosphere which were of importance for forecasting the possibility of aircraft making condensation trails. During this work it was found that 'sublimation nuclei' (that is, nuclei on which water vapour would condense directly to ice crystals if below 0° C.) were very much rarer than was expected. Later, Cwilong was anxious to investigate this point further by using a Wilson cloud chamber at controlled temperatures below the freezing point, and he stayed on at Oxford for this work and to take a D.Phil. degree.

While his results had, unknown to him, been partly anticipated by Findeisen in Germany, they were of great interest. He developed an ingenious method of detecting the presence of a single ice crystal if formed in the cloud chamber, and showed that there were, indeed, exceedingly few nuclei on which water vapour would condense directly to ice at temperatures only a few degrees below 0° C. He showed further that, as the temperature was lowered, more and more nuclei became 'active' until at about − 40° C. water vapour would condense to ice on almost all nuclei. After leaving Oxford, he held lectureships in physics at Vancouver and in New Zealand, working mainly on atmospheric nuclei, but also, for a time, on low-temperature physics.

Cwilong was an outstanding chess player, but his greatest interest was in sailing at sea and he had twice been around the world in a sailing ship. After leaving Oxford, his great ambition was to obtain a non-magnetic yacht and make a magnetic survey of the Pacific Ocean. At his own expense, he bought a yacht in England and sailed it across the Atlantic and, after taking it through the Panama Canal, he set out to sail up the west coast of North America with only himself and his wife on board. A few days out they had the misfortune to run into a tropical hurricane and, though he had taken down all sail, the yacht was dismasted due to the violent rolling of the boat in the terrific seas that followed the storm. After this he was forced to return to Panama. Very characteristically, he wrote to me: "We both had hard times, but to me sailing through a hurricane was a very interesting experience".

Soon after this his health became poor, though he continued to work on atmospheric nuclei both in Panama and at Kew Observatory. All the time he was still planning another magnetic survey of the Pacific Ocean, but he did not live to carry it out.

G. M. B. Dobson

Mr. J. H. Grace

Mr. John Hilton Grace, who died at Huntingdon on March 4, was born on May 21, 1873, and was educated at the Liverpool Institute and at Peterhouse, Cambridge. He was second wrangler, bracketed with E. T. Whittaker, in 1895; the senior wrangler of that year was T. J. I'A. Bromwich. He was elected a Fellow of Peterhouse in 1897 and served as a College and University lecturer until 1922; when at his best he was a brilliant teacher. Since 1922 he had lived in retirement.

Grace wrote a standard book on "The Algebra of Invariants" together with A. Young, and a number of papers on topics in algebra and geometry. Most of these papers are short and are notable for the elegance of the results and the power of the methods. Grace's early work led to his election to the Royal Society in 1908.

J. C. Burkill

NEWS and VIEWS

Macaulay Institute for Soil Research: Dr. D. N. McArthur, C.B.E.

Dr. D. N. McArthur, who has retired from the directorship of the Macaulay Institute for Soil Research, Aberdeen, commenced his research career as physical chemist to the West of Scotland Radium Committee, but most of his earlier work was done at the West of Scotland Agricultural College where he was professor of agricultural chemistry from 1928 until his appointment as director of the Macaulay Institute in 1945. At that time the staff of the Institute consisted of only fifteen scientists with some technical assistants but, under his vigorous leadership and his exploration of new lines of research on all aspects of soil science, he gathered round him a band of young scientists so that the scientific staff now numbers forty-four. Most of the development has been in fundamental research, but not the least of Dr. McArthur's achievements has been his success in keeping these purely scientific studies harnessed to the more practical aims of the Institute, and in maintaining the closest connexion between all the very varied lines of investigation. Under his guidance the Institute has become a centre of scientific knowledge on all aspects of soil, and its advice has been sought both by government and private bodies in Britain and throughout the Commonwealth. His insistence on the high quality of the research done at the Institute has given it a world-wide reputation and has brought to it young research workers from all parts of the world. Dr. McArthur serves on many departmental and national councils, and is chairman of committees advising the Secretary of State for Scotland on spectrographic work, manurial values, and moss survey. He was made C.B.E. in 1953.

Prof. A. B. Stewart

Prof. A. B. Stewart, Strathcona-Fordyce professor of agriculture at the University of Aberdeen, has been appointed director of the Macaulay Institute for Soil Research in succession to Dr. D. N. McArthur. Prof. Stewart commenced his research work on soils under the late Prof. Hendrick at Aberdeen and Prof. Wiegner at Zurich, and was appointed to the Macaulay Institute in 1932 to take charge of a newly established department to deal with soil fertility. His studies there ranged over, not only the soil and the plants it supported, but also the health of the

animals consuming the crops, and were followed through by means of field, pot and laboratory techniques. Much advisory work went hand-in-hand with these investigations. For the nine years before his appointment in 1954 to the chair of agriculture in the University of Aberdeen he was deputy director of the Institute. In 1945 Prof. Stewart was invited by the Government of India to advise on problems of soil fertility and crop production and spent six months there on this study. His suggestions for the planning and conduct of future experimental work contained in his report published in 1947 have been widely followed in India. Another special investigation, this time for the Development Commission, was a survey in conjunction with Dr. F. N. Woodward and the late Mr. J. P. Maxton of agricultural, forestry and fishery products in the United Kingdom and their utilization. Prof. Stewart has been appointed to many government committees, and at the present time he is chairman of the Board of Management of the Hill Farming Research Organization.

Eastman Visiting Professor at Oxford : Prof. G. W. Beadle

Dr. George Wells Beadle, professor of biology and chairman of the Biology Division at the California Institute of Technology, has been appointed the Eastman visiting professor at the University of Oxford, for the academic year 1958–59. Dr. Beadle, who was born in Wahoo, Nebraska, in October 1903, received his academic training at the University of Nebraska and at Cornell University. He was a National Research Council Fellow at the California Institute of Technology during 1931–33 and an instructor there until 1935. During the following year he was a guest research scientist at the Institut de Biologie Physico-chimique at the University of Paris, where he worked on genetics with Dr. Boris Ephrussi. In 1936, Dr. Beadle went to Harvard as assistant professor of genetics and in 1937 he became full professor at Stanford, where he remained until he became chairman of the Division of Biology at the California Institute of Technology in 1946. During the year 1956–57 he was president of the American Association for the Advancement of Science.

The Eastman professorship was founded in 1929 by George Eastman to send senior American scholars to the University of Oxford for a year. During twenty-eight years the list of Eastman professors has included such distinguished men as Felix Frankfurter, Arthur H. Compton, John Livingston Lowes, Linus Pauling, Wallace Notestein, and Harold C. Urey. The Eastman professor during the current academic year is George Kennan, former American Ambassador to the U.S.S.R. and a member of the Institute for Advanced Studies at Princeton.

Department of Scientific and Industrial Research, Stevenage : Mr. S. H. Clarke, C.B.E.

Mr. S. H. Clarke, who has been appointed director of the new Research Station now being built for the Department of Scientific and Industrial Research at Stevenage for fuel and process research, is the present director of the Fire Research Station at Boreham Wood, run jointly by the Department of Scientific and Industrial Research and the Fire Offices Committee. After taking his degree from the University of Nottingham, at that time the University College, he joined the Forest Products Research Laboratory in 1927. In 1939 he was seconded to the Research and Experiment Department of the Ministry of Home Security. He was appointed the first director of fire research in 1946 when the Joint Fire Research Organization and the Fire Offices' Committee was set up. The programme of the new Research Station will include, as major items, researches on atmospheric pollution, the production of oil from coal and aspects of mineral processing.

The National Zoological Park, Washington : Dr. T. H. Reed

Dr. Theodore H. Reed, who has been appointed director of the National Zoological Park at Washington, was first appointed to the staff in July 1955 as chief veterinarian, a position he held until November 1956, when he became acting director upon the retirement of Dr. William Mann (see *Nature*, **178**, 1095 ; 1956). A graduate of veterinary medicine at Kansas State College, Dr. Reed was assistant veterinarian of the State of Oregon, in Portland, for several years and was in private practice in that State, Idaho, and Minnesota. He was also an active participant in organizing the Portland Zoological Commission and the Portland Zoological Society. J. Lear Grimmer, who is a zoologist with a special interest in herpetology, has been appointed associate director of the National Zoological Park.

River Studies at Reading

The University of Reading has recently established a River Studies Centre on the bank of the Thames near the Borough. Accommodation has been allotted to the Departments of Botany, Geography, Geology and Zoology ; a strip of ground running beside the river for several hundreds of yards, and an island about a mile downstream, also belong to the University. The biological accommodation consists of two laboratories and an aquarium room, containing a number of tanks which can be filled directly from the river. The Thames Conservancy has granted permission for the removal of fish of all kinds at all times of the year from the reach between Caversham Lock, in Reading, and Sonning Lock, about 3½ miles downstream. For sampling the fish population, a large seine net has been purchased, and by intensive marking and recapturing it is hoped that figures will be obtained for the rates of birth and death. This, and other possible investigations, have recently been described by K. H. Mann (*J. Inst. Biol.*, **5**, No. 2; February 1958). It is hoped that an investigation of the invertebrate fauna will proceed at the same time as the fish studies. Molluscs such as *Anodonta*, *Unio* and *Valvata* are abundant in the river bed, and may provide useful material for population studies. It is likely that a good deal of information will also be collected in the fields of hydrography, meteorology and sedimentology, and it may be possible at a later date to effect a synthesis of the biological, physical and chemical observations.

Nuclear Engineering

A Department of Nuclear Engineering, for students of the peaceful applications of atomic energy, is to be established at the Massachusetts Institute of Technology. Dr. Manson Benedict, professor of nuclear engineering, has been appointed head of the Department. The 2,640,000 dollar nuclear reactor at the Institute, which will be completed this spring, will serve as a laboratory for the new Department, enabling students to make first-hand studies of

atomic energy produced by the fission process. The teaching programme will dovetail with a research programme, which will include studies of atomic energy for medical and industrial as well as scientific purposes.

End of the Second Artificial Earth Satellite

It is reported from Moscow that Sputnik 2 (Satellite 1957β), which was launched on November 3 with the dog 'Laika' on board, re-entered the denser layers of the Earth's atmosphere and disintegrated over the South Atlantic on the night of April 13–14. A large meteor, presumed to be the remains of the satellite just before it burnt out, was observed shortly after 01.50 G.M.T. on April 14 travelling from north-north-west to south-south-east from Barbados and by the Dutch tanker *Mitra* off the Virgin Islands. The artificial Earth satellite had remained in its orbit for 162 days and had executed about 2,370 revolutions of the Earth.

The Mathematical Association

At the annual general meeting of the Mathematical Association, held at Manchester during April 10–12, the president, Mr. W. J. Langford, headmaster of Battersea Grammar School, spoke on "Secondary School Mathematics: an International Survey". Mr. Langford's wide experience, and his work at the Geneva conference of the International Bureau of Education, enabled him to summarize a great deal of information about the aims and methods of mathematical teaching. He found general agreement that mathematics is essential not only as a foundation for scientific and technical studies but also as a primary source of cultural enrichment. Whereas methods in the United Kingdom are as up to date as anywhere in the world, British teachers are more frequently envied for their freedom from official instructions on methods and text-books, and for their dominating influence on the framing of syllabuses.

Mr. Langford also dealt with the serious shortage of qualified teachers of mathematics. He dismissed as useless the frequently repeated assertion that we must double the number of technologists by 1970, since neither teachers nor suitable students are available. He suggested the more realistic approach, first, of estimating the numbers of boys and girls who in 1960 would be coming out of the sixth forms capable of reading mathematics (1) for an honours degree, (2) as part of a general degree, (3) as a special subject for the teaching certificate. We must then assure the further education of these students, in both schools and colleges, by a proper deployment of the resources of these institutions and by extending systems of maintenance grants. Finally, we must make the fullest use of available qualified teachers and avoid the gross waste which occurs when teachers take up appointments in which their special qualifications are not used to full advantage; this must be done by control of appointments, not by direction of labour. These measures should guarantee the best use of available resources; but they will not of themselves suffice, unless we can ensure an adequate supply of competent young people enthusiastically determined to devote themselves to a life of teaching.

Scientific Arrogance

In the *Portsmouth Diocesan News* of March, the Bishop of Portsmouth comments on the reported attack on scientists in general by the Bishop of Coventry, which was described as arrogant. This misinterpretation arises out of the reference in the sermon to some scientists who, "on the air speak as though they had the key to all knowledge and that God is now outmoded, as though he were the invention of the simple-minded". The Bishop of Portsmouth points out that scientists are sometimes quite falsely charged with views about religion which only some of them hold and which, in any event, they hold or reject as men and not as scientists. The word 'scientific' is often loosely attached to theories of the universe or points of view which are not scientific at all, even though they may be ways in which the results of scientific knowledge may be interpreted, and the tendency to regard all scientists engaged in nuclear research as rather sinister beings whose inventions may all too easily destroy the world is equally misleading. While the continually advancing new powers placed by scientific research and techniques within man's reach are the business of scientists, the way in which these powers are used is a religious and moral issue, in which all are involved, including the scientists themselves. It is not arrogant for the scientist to make known the results of his research and to give some idea of the possibilities which they place within man's reach, but humility as well as vision and judgment are called for when we consider how this knowledge may be rightly used and especially questions relating to the scientific techniques by which man can bring about changes in himself. The Bishop suggests, however, that those who preach and teach the Christian faith may be guilty of a different type of arrogance if they lack a sense of mystery and wonder. The person of Christ, he claims, leads us deeper into the mystery of truth and makes plain both the truth of God and the truth of man's nature.

Freedom in Research

Dr. J. R. Baker's address "Freedom in Research" before the Uganda Scientists' Club at Makerere College, Kampala, on August 6, 1957, has been reproduced as Occasional Pamphlet No. 17 by the Society for Freedom in Science (Oxford: University Museum, 1957). Dr. Baker reviews first the way in which the Society for Freedom in Science came into being to combat the idea that science existed solely for the material benefits it brings to mankind and that there is no distinction between science and technology. The members of the Society, he pointed out, were concerned to uphold two main principles. First, they believed that science had a value to society apart from the material advantages it might bestow, and secondly, they held that first-rate work in science could only be done if scientists were free to pursue their researches without control by any central authority. Dr. Baker did not suggest that a scientist should regard himself as free of all obligations to the community: it was his duty to address himself to the largest problems he was capable of tackling, but he could not tell whither the trail would lead and it was futile to guess how his discoveries might affect the community as a whole. Often the most important researches in science led to no specific practical advantage but formed a necessary foundation on which the practical now must stand. Nevertheless, the problems of technology were not the same as those of science, and it was a mistake to confuse science with technology and imagine that the same principles govern both. Each man must be clear as to his purpose and demand or submit to the conditions that made his work possible.

Growth of Government

The Broadsheet, "The Growth of Government" (No. 417), recently issued by Political and Economic Planning, discusses briefly the main changes in the scale and character of government over the past fifty years. It provides a useful introduction to such current questions as the pressure on Ministers and senior Civil servants and the reform of administrative tribunals, as well as of other emerging problems, some of which are indicated. Reviewing first the functions and scale of government, it notes that whereas in 1901 only some 958,000 persons (including the armed forces and local government employees) out of 38 millions, or 5·8 per cent of the working population of 16 million, were in government employment, by 1950 this figure had risen to 3,214,000, or nearly 14 per cent of the working population of 24 million, or 24 per cent if employees of the nationalized industries are included. Excluding the Post Office, the non-industrial Civil Service had increased from 28,000 established members in 1902 to 387,000 in 1955, passing a peak of 459,000 in 1949. Financially, it is estimated that 19 per cent of all incomes (or 29 per cent including the nationalized industries) arises in the public sector and that 10 per cent of the gross national product (plus 10 per cent for the nationalized industries) is produced in the public sector. Budget figures rose from about 8 per cent of the national income figures in 1904–5 to 24 per cent in 1919–20 and 32 per cent in 1954–55. Broadly, the government share of the working population is nearly three times, and its share o national resources at least four times, as great as in the 1900's. Local government employees increased from 375,000 in 1901 to 1,422,000 in 1950, the increase being mainly before 1939, but semi-independent bodies have increased enormously; and some private, self-governing bodies, like the British Standards Institution and the Finance Corporation for Industry, have acquired a form of public status and responsibility.

National Fuel Policy

On March 24 the Paymaster-General, Sir Ian Horobin, said in reply to a question in the House of Commons regarding the future of the coal industry that although the contributions of nuclear energy and oil are essential towards meeting our growing needs for energy, coal will remain the foundation of British fuel economy for many years. We must, therefore, have an efficient coal industry producing the grades required in the appropriate quantities and at reasonable prices. Large-scale capital investment will continue to be needed for this purpose. On March 31, Sir Ian said that the recent re-phasing of the nuclear power programme, as part of the general revision of capital investment, now provides for the installation of 5,000–6,000 MW. of capacity by the end of 1966, and will increase the consumption of coal by power stations by three million tons a year. No further change in the programme is contemplated at present, and Sir Ian declined to add to his previous reply about capital investment in the coal industry. The whole question of energy and capital investment is periodically reviewed; but while savings are anticipated in the capital cost of nuclear power stations, no major change in the programme is warranted in the immediate future, although developments have occurred which promise to cheapen the product from such stations.

Application of Science to Industry

A long motion on the application of science to industry, moved by Mr. R. E. Prentice in the House of Commons on April 28, quoted the estimate of the Advisory Council for Scientific Policy that industry was only spending 0·8 per cent of its output on research and development, and referred to the affiliation of only 520 firms out of a potential 10,000 to the Production and Engineering Research Association. Mr. Prentice suggested that an attitude of self-satisfaction is still too widespread in British industry. Referring to the last two annual reports of the Department of Scientific and Industrial Research, he questioned whether Government-financed research is proceeding on an adequate scale. He also asked whether, having regard to the expenditure on defence of 59 per cent of our total scientific research and development effort, one could be sure that priorities were right, and he suggested that overall strategy on scientific matters was lacking. From the national point of view, he believes that the Lord President of the Council or some other senior minister should have full-time responsibility for scientific policy and the Advisory Council should be strengthened by more representatives from both sides of industry. We need an entirely new public attitude to science and its use by Government and industry. Members of Parliament could give a lead, but more attention by trades union branches is also required. Only fifteen minutes were allowed for the debate and the Parliamentary Secretary to the Board of Trade had one minute to reply.

Primary Schools in the Transvaal

In 1953 the Department of Education of the Transvaal Provincial Administration set up a committee to report on schools building research. Already reports have been published of investigations made into school furniture, the selection of sites for school and hostel buildings, the layout of playing fields and grounds, and school halls. The committee has now issued a detailed report on "The Planning of Primary Schools" (Report of the School Buildings Committee, 1957. Pp. 86. Pretoria: Government Printer, 1957). This is centred on the needs of the child, and gives a clear recommendation about such topics as the most suitable class-rooms, communal rooms and administrative offices. The types of school most suitable for one- and two-standard entry primary schools are described, while detailed cost analyses are also included. The need for co-operation between all those responsible for school design is constantly stressed, particularly close co-operation between the educator, the architect and administrative officers being advocated. Published in Afrikaans and English, the report is clearly illustrated and should serve as a guide in countries other than South Africa.

South African Museum

The annual report of the South African Museum for the year ending March 31, 1957 (pp. 21. Cape Town: South African Museum, 1957), records the great activity of this institution at Cape Town under the energetic guidance of the new director, Dr. A. W. Crompton. The Trustees are grateful for the increased facilities for salary adjustments, holiday bonuses and research work granted by the Minister of Education, Arts and Science—the latter is already reflected in

an impressive list of published material by the staff—but they point out that the present grant-in-aid is only sufficient to maintain the Museum as a relatively static organization. In such circumstances, progress is difficult, and the fact is emphasized that, in common with other museums, a relatively small increase in the annual grant would enable the institution to act as an efficient and educational centre. The importance of the policy of collecting material is stressed, and it is satisfactory to note the result of two geological expeditions in the field lasting for several weeks.

Translations of Russian Scientific Literature

In a written answer to a question in the House of Commons on April 1, Mr. H. Nicholls, Parliamentary Secretary to the Ministry of Works, as representing the Lord President of the Council, said that the Department of Scientific and Industrial Research is at present purchasing copies of most translations of Russian scientific literature produced in the United States. Discussions are in progress between the Department and the National Science Foundation with a view of improving the present arrangements for the interchange of translations.

Leeds University Library

The annual report of the Librarian, University of Leeds, for the session 1956–57 (pp. 12. Leeds: The Brotherton Library, The University, 1957) records holdings of 412,809 and 170,006 pamphlets on June 30, 1957, of which 293,962 volumes and 113,833 pamphlets are in the Brotherton Library. Accessions during the year totalled 12,369 volumes, 3,325 pamphlets and 26,951 periodical parts; 49,363 slips and cards were added to the catalogues, 4,872 books were sent to the binder, and of 97,924 loans to readers, 62,195 were by the Brotherton Library, 16,182 by the Institute of Education and 11,806 by the Medical Library. Reviewing the quinquennium, it is pointed out that only the steady increase of the book fund has enabled the Library to maintain the standard of the 1947–52 quinquennium for purchases of books and periodicals, but increase in senior staff was precluded, cataloguing and classification decreased and binding was restricted to current and urgent needs. The use of the Library, particularly of the main library where the pressure on seating is concentrated, is the subject of special inquiry by the Nuffield Foundation.

Indian Scientific Documentation Centre

The annual report for 1956–57 of the Indian National Scientific Documentation Centre (New Delhi: National Physical Laboratory of India, 1957) records a further increase in the demand for the Centre's services. Copies of 4,305 scientific papers were supplied during the year, compared with 3,939 in 1955–56, and of these 27,806 pages were in photocopy and 102,290 as microfilm: 33·5 per cent were from libraries in Delhi and 13·8 per cent from libraries elsewhere in India. Translations of 701 articles were also requested, as compared with 570 in 1955–56, and 637 were completed, chiefly from German (252), French (132) and Russian (101). 120 bibliographies were compiled, representing 230 pages compared with 147 in 1955–56: 110 requests for bibliographies were received. With the holdings of the National Physical Laboratory library, the Centre's library now contains more than 26,000 volumes, and about 1,200 scientific publications are currently received. The list of current scientific literature is issued twice-monthly. The Centre also issues the "Bibliography of Scientific Publications of South and South-East Asia" and the *Annals of Library Science*, and maintains a master index of the translations carried out in the Commonwealth, notified through the British Commonwealth Scientific Organization.

Forty Years of Soviet Science

The Russian popular science monthly *Priroda* of November 1957 is devoted to the fortieth anniversary of the Soviet regime. It contains 15 articles concerned with the progress of science and technology during the past forty years. Three of these articles are of a general nature, the others discuss advances made in the study of fundamental particles and the atomic nucleus, semi-conductors, geology, chemistry, mathematics, astronomy, agriculture, geography, while the last four articles are devoted to the progress of science in Kazakhstan, Latvia, the industry of the Urals and on the Soviet expedition in the Antarctic.

International Journal of Health Education

In 1951 the International Union for Health Education was founded as a non-governmental organization designed to contribute to the development of health education throughout the world. It has already arranged important international conferences, the last one, which met in Rome during May 1956, attracting 1,500 participants from more than fifty countries. The Union has now launched a journal, the first issue of which reflects its international character (*International Journal of Health Education*, 1, No. 1 (January 1958). Pp. 64. Annual subscription rate: 12 Swiss francs; 3 dollars. Geneva: International Journal of Health Education, 3 rue Viollier, 1958). Besides articles of a general character, there are accounts of health education developments in Japan, the U.S.S.R., Africa, Turkey and Ecuador; details of recent books, films and other visual aids are also included.

World Low Air Temperature Record

A world record low air temperature −102·1° F. was observed in the screen (2 m. height) at the United States Amundsen–Scott International Geophysical Year station at the South Pole at 2137 G.M.T. on September 18, 1957. The full report, given in the *Monthly Weather Review*, November 1957, p. 326, is as follows: *Wind*, 4 kt.; *temperature*: surface, −103·3° F.; 2 m., −102·1° F.; 5 m., −101·0° F.; 10 m., −79·5° F. It will be seen that there was an intense inversion of more than 23° F. between the surface and 10 m. The previous world record was −100·4° F. registered at the South Pole on May 11, 1957. The record which stood for many years was −90° F. at Verkhoyansk, north-east Siberia, on February 5 and 7, 1892.

Life Insurance Medical Research Fund of Australia and New Zealand

The Life Insurance Medical Research Fund of Australia and New Zealand, established by the Life Offices' Association for Australasia to promote and assist scientific and medical research, is offering grants-in-aid to non-profit institutions with basic facilities and qualified personnel for medical research to be used in support of a specific programme of investigation under the direction of a particular investigator. Both fundamental and clinical research projects in the field of cardiovascular function and

disease will be supported. Grants will usually be from £1,000 to £3,000 per annum, to cover all the financial requirements of the programme.

The Fund is also offering Research Fellowships, which will be open to medical graduates or those with equivalent scientific training, for full-time research on fundamental problems broadly related to cardiovascular function and disease or for clinical investigations in these fields. Fellowships taken up in Australia or New Zealand for work in an approved institution will range from £1,800 to £2,000 for the term of one year in the first instance. Travelling Fellowships will be granted for a period of two years abroad, followed by a third year in an approved institution in Australia or New Zealand. The award will range from £2,000 to £2,250 per annum, and approved travelling expenses will also be allowed. Further information and application forms (to be returned before July 1) can be obtained from Dr. John H. Halliday, Medical Director, Life Insurance Medical Research Fund of Australia and New Zealand, 87 Pitt Street, Sydney, New South Wales.

Grants for Graduate Research

A revised edition of the "Notes on D.S.I.R. Grants for Graduate Students and Research Workers" (pp. 22. London: H.M. Stationery Office, 1958. 1*s.* 6*d.* net) gives details of the awards which, under the new arrangements, the Postgraduate Training Grants Committee and the Research Grants Committee are prepared to recommend to the Research Council of the Department of Scientific and Industrial Research. The studentships of the former Committee comprise research studentships (formerly known as maintenance allowances) for postgraduate training in methods of research; advanced course studentships (a new award) for advanced courses of postgraduate instruction in science and technology; and Department of Scientific and Industrial Research fellowships, formerly known as senior research awards, for outstanding young investigators already trained in methods of research. The Research Grants Committee recommends grants for special research, to help investigators of acknowledged standing to initiate and develop promising investigations. The awards do not include the research fellowships in Government establishments awarded annually on the recommendation of the Civil Service Commission.

As a result of recommendations made by the Willis Jackson Committee on the Supply and Training of Teachers for Technical Colleges, the number of places available for students who wish to train to become technical teachers is to be increased by more than 60 per cent and substantially higher rates of grants will be paid to students, though full details of the new scales of grants will not be known before completion of the triennial review of the standard figures of maintenance for students at universities and of training college grants now in progress. The final settlement will include increased personal grants to students, together with travelling expenses. It is expected that the technical colleges will need to recruit more than 2,000 new full-time teachers a year.

Royal Society of Tasmania: Officers

The following were recently elected to office in the Royal Society of Tasmania: *President*, The Rt. Hon. Sir Ronald Cross, Governor of Tasmania; *Vice-Presidents*, Mr. J. W. C. Wyett and Mr. L. W. Miller; *Council*, Mr. C. Bisdee, Mr. Justice Crisp, Dr. W. E. L. H. Crowther, Mr. R. M. H. Garvie, Dr. E. R. Guiler and Mr. K. D. Nicholls; *Hon. Treasurer*, Mr. G. E. A. Hale; *Hon. Auditor*, Mr. A. M. Hewer; *Hon. Secretary and Librarian*, Dr. W. Bryden; *Librarian*, Miss E. M. Geddes.

Announcements

Dr. Vivian Fuchs, leader of the Commonwealth Trans-Antarctic Expedition, has been elected a member of the Athenæum under the provisions of Rule 2 of the Club, which empowers the annual election by the Committee of a certain number of persons of distinguished eminence in science, literature or the arts, or for their public services.

As indicated in recent annual reports, the Carnegie Institution of Washington is withdrawing from the field of Middle American archæology. On July 1, 1958, the offices of the Department of Archæology, at 10 Frisbie Place, Cambridge, Massachusetts, will close, and the Department will cease to exist. After that date all correspondence concerned with the past activities of the Department should be addressed to Carnegie Institution of Washington, 1530 P Street, N.W., Washington 5, D.C.

The Food and Agriculture Organization of the United Nations has announced that it will offer eight to ten André Mayer Fellowships in 1958. These Fellowships will be awarded only to persons with the highest qualifications for research work in agriculture, agricultural economics and statistics, fisheries, forestry and nutrition. Further information can be obtained from the Secretariat of the F.A.O. National Committee for the United Kingdom, c/o Ministry of Agriculture, Fisheries and Food, Whitehall Place (East Block), London, S.W.1.

The World Congress of Gastroenterology will be held in the Sheraton Park Hotel, Washington, D.C., during May 25–31. Further information can be obtained from Dr. H. M. Pollard, secretary-general of the Congress, University Hospital, Ann Arbor, Michigan.

The Thames Valley Section of the Royal Institute of Chemistry is holding a symposium on "Radiation Chemistry of Organic Systems", by courtesy of the U.K. Atomic Energy Authority at Cockcroft Hall, Harwell, on May 9. Papers will be reviews rather than specialized accounts of original research. Further information can be obtained from Dr. E. S. Lane, Chemistry Division, Building 429, Atomic Energy Research Establishment, Harwell.

The next standard Reactor School Course at Harwell, on which places are available, will commence on September 1 and finish on December 23. The first six weeks of the course will be held jointly at Birmingham, Bradford and Salford Colleges of Advanced Technology, and the remaining part at the Harwell Reactor School commencing on October 15. The fee for the course, which is open to British and overseas students, is £250. Selection of successful applicants will be made on June 2. Further information can be obtained from The Principal, Harwell Reactor School, Atomic Energy Research Establishment, Harwell, Berkshire.

Erratum. In the communication entitled "Effect of Gibberellic Acid on Fruit Set and Berry Enlargement in Seedless Grapes of *Vitis vinifera*" by Dr. Robert J. Weaver in *Nature*, March 22, p. 851, a mistake has occurred in Table 1; the average weights of clusters given in col. 2 are in 'pounds', not 'grams' as printed.

EXCHANGE OF TECHNICAL INFORMATION

THE Defence Contracts Bill, which received its second reading in the House of Commons and was committed to a Standing Committee on December 12, 1957, is concerned primarily, as the President of the Board of Trade, Sir David Eccles, explained in opening the debate, with the use in defence contracts of technical information which is not the subject of a patent or registered design. Its main object is to revoke certain emergency powers at present possessed by the Government and to substitute limited but permanent powers enabling such technical information, which may be the product of much experiment and development work, to be used for defence purposes. These existing powers are possessed by the Government under the Patents Act, 1946, and the Registered Designs Act, and for this reason, and because the Board of Trade is responsible generally for questions of industrial property, the Bill was sponsored by the President of the Board of Trade.

The Bill is the second attempt made since 1951 to revise the law dealing with the use of patented inventions and registered designs for the services of the Crown. The Inventions and Designs (Crown Uses) Bill introduced into the House of Lords in December 1953 permanently empowered Government Departments to authorize the "use" and "disclosure" of technical information for "the services of the Crown". These powers were strongly opposed in the second reading debate, Lord Rochdale pointing out that under its terms anybody could be compelled to disclose information not only to a Government servant but also to a third party, possibly one of his competitors, who might then publish what he had learnt. The Bill was withdrawn, and as a result of discussions between Government Departments and industry, a small committee was appointed, with Sir Harold Howitt as chairman, to inquire into the desirability of any such permanent powers and the conditions under which, if necessary, they should be exercised.

The Committee reported in June 1956 and the new Bill, which is intended to remove the grounds for complaint voiced by Lord Rochdale, is based on the recommendations of the report. The Committee received evidence that industry now relies to an increasing degree on detailed information, such as working drawings, models, designs, technical records, and details of workshop practice, which is either unpatentable or is not in practice patented. Such technical information is frequently exchanged between firms under agreements which provide, apart from payments, for maintenance of secrecy and for restrictions on the use of the information by the recipient in the interest of the supplier or licensor. The preservation of secrecy is important since such information may be the result of many years of research, development and trial, but only after considerable reflexion did the Howitt Committee conclude that the balance of argument was in favour of the Government being given permanent powers in place of the present Defence Regulations issued during the Second World War, which enabled contracting Departments to authorize the use of such information for defence and other purposes.

Nevertheless, the Howitt Committee recommends the full maintenance of the secrecy provisions of existing agreements: there should be no power whatever to require "disclosure" as distinct from "use", and the powers should be limited to defence requirements, which should be narrowly defined. Before these powers are exercised the parties concerned should be given three months to negotiate new agreements, and only if these negotiations fail to produce results deemed satisfactory by the Government should the Government have power to override any term of the agreement. Such power, moreover, should only be exercised after consideration of each individual case at a high level, and any person adversely affected should have the right of fair and just compensation and of appeal to a judge of the High Court, sitting, if requested by the parties, with two assessors agreed by the parties or appointed by the Lord Chancellor.

The Committee believes that these proposals ensure that an overseas manufacturer, having developed a technique which he regards as of great value to himself, should have no reason to fear that it might be divulged to some third party as a result of the exercise of Government powers. Incidentally, the Committee directs attention in this report to the need to clarify the Section 27 (1) of the Patents Act, 1949, which purports to deal with technical information relating to patented inventions. It should be made clear, it suggests, either that this section was intended to deal with technical information relating to patented invention, there being some special reason why it should be dealt with separately in that way, or that the section was inadvertently enacted in wider terms than was intended or contemplated, in which event amending legislation would be appropriate.

The Defence Contracts Bill terminates the current period of emergency in which additional powers to use patented inventions and registered designs are conferred on the Crown under the Patents Act, 1949, and the Registered Designs Act, 1949, and makes it clear that statutory provision for the use of models, documents and information does not authorize disclosure to the Government or any other person in contravention of any contractual restriction. Clause 2 of the Bill makes permanent provision for the use by Government contractors, for the production of defence materials, of technical information in their possession which is protected by contractual arrangements, subject to the safeguards recommended in the Howitt report. The term 'defence materials' is interpreted to cover, first, articles designed or adapted for the use of the Armed Forces of the Crown, or for supply to allied countries for their defence, and components of such articles; secondly, articles designed or adapted for civil defence purposes, and their components; and thirdly, articles required for the production, repair or maintenance of such articles.

This definition of defence materials follows the recommendation of the Howitt Committee; but obviously could lead to difficulties in the case of supplies of defence materials to allied countries. It was on this point that a rather unsatisfactory debate

seemed to concentrate and also on the limitation of the Bill to the defence services. Sir Frank Soskice, and also other Opposition speakers, while concerned at the implications for industry of the Bill as regards the supply of defence materials to allied countries, ignored the assurance of the Howitt Committee on this point. On the other hand, he sought to extend the scope of the Bill to cover contracts for other services of the Crown, especially the health services. The trend of his remarks regarding the disclosure of technical information are indeed disturbing. It would be most unfortunate if industry came to rely excessively upon secrecy rather than upon patents, even if the patent law were more unsuited to the needs of British industry to-day than appears to be the case.

In a recent article on this subject in the *Journal of Industrial Economics* (5, 157; 1957), Mr. C. A. Bloxam expressed the opinion that the patent system is the only one so far devised which reconciles the encouragement of technological innovation by commercial interests with encouragement to make available to the public the maximum amount of information regarding such innovations. Mr. Bloxam's inquiry has satisfied him that it also offers effective safeguards to prevent the use of patents for suppressing inventions; indeed, a particularly interesting part of Mr. Bloxam's article is that in which he presents reasons for believing that patents are not suitable instruments for suppressing invention. The article is worth noting in this connexion as setting the issues raised by the Bill in the context of those which determine the rate of application of science and technology in industry, particularly in view of the comparatively sterile debate referred to; the latter makes desirable a more objective discussion such as is to be found in the report on industry and technical progress prepared for the Science and Industry Committee of the Royal Society of Arts, the British Association and the Nuffield Foundation.

Sir Frank Soskice did not suggest that information should be disclosed to rivals, but he appeared to take a remarkably optimistic view as to the safety of information disclosed to Government departments, an optimism that is unlikely to be shared by the overseas manufacturer whom the Howitt Committee rightly had in mind. There is a question of confidence here which is particularly important if British industry is to take the fullest advantage of the opportunities for development to which Mr. J. H. Dunning has directed attention. Furthermore, this question of technical information is particularly important in regard to research and development in pharmaceuticals, which would appear to be one aspect of the health services that Sir Frank Soskice had in mind.

Mr. W. R. Rees-Davies, in supporting the Bill, was much more practical. He recognized that it might be necessary to widen the powers of the Bill later; but he held that the experience gained under the present Bill would give a much clearer idea of the practical difficulties and how best to handle the question of private contracts. Sir David Eccles, in replying on the debate, was emphatic that at present overseas manufacturers would be unwilling to enter into agreements involving the supply of technical information to British firms, if the Government possessed the wider powers which the Opposition sought to write into the Bill.

The problem is undoubtedly difficult, and the debate failed to give weight to some of the factors to which the Howitt Committee directed attention. It is, in fact, intimately related to the vital question of Anglo–American co-operation. Britain benefits greatly, as the Howitt Committee observed, throughout the whole economy, from the use of the knowledge developed particularly in the United States; and currency difficulties, geographical propinquity and sentimental ties all lead Commonwealth and Western European countries to turn more readily to the United Kingdom than to the United States. Anything which checked this interchange of information, or discouraged the practice of some American companies of allowing their British associates to exploit in Britain and elsewhere the techniques which they have developed, would have serious repercussions on the British economy. It is to be hoped that this wider issue will be more fully and objectively discussed in the subsequent proceedings in Parliament.

TECHNICAL STUDENTS IN BRITAIN

In speaking at a residential course for teachers in schools and technical colleges at St. Annes-on-Sea on January 21, Mr. A. A. Part, Under-Secretary in charge of the Further Education Branch at the Ministry of Education, said that the Minister had asked the Central Advisory Council for Education to make a special inquiry into the wastage of students in some of the main part-time courses in technical colleges. The inquiry was needed to provide more evidence from which the facts could be studied and, after referring to figures recently quoted by Lady Gertrude Williams and Dr. G. B. Frisby, director of the National Institute of Industrial Psychology, Mr. Part said that even without a special inquiry it could be seen that more practicable courses like the new course in mechanical engineering craft practice were required. It was also necessary to re-emphasize the relatively high standard of the National Certificate, and that this, even in its first three years up to Ordinary National Certificate, was designed for future technicians and technologists and was suitable only for those craft apprentices with an academic background above average and who showed strong promise of being able to rise out of the ranks of craftsmen. The really substantial wastage occurred at the beginning of the course, and available evidence suggested that very few of those who failed at the end of the first year of the course ultimately obtained an Ordinary National Certificate. Mr. Part believed that too many students were being admitted either with inadequate ability in mathematics or with too narrow an academic background, or both.

Mr. Part said that the weakness of many of the present arrangements lay in the inadequate standards of entry required by some colleges; the rigidity of some apprenticeship schemes, or their inflexible local interpretation; the often unsuccessful interpolation of several terms at an evening institute between leaving school and starting a National Certificate course; and the temptation to some schools to narrow studies in the last year so as to concentrate on the three subjects normally required for the examination

at the end of a "pre-S.1 course": mathematics, science and technical drawing. The main answer seemed to lie in the establishment by the colleges of standards of entry high and broad enough to ensure a much greater chance of success than is usual at present. These standards should apply to all National Certificate aspirants.

Summing up, Mr. Part visualized openings for some 3,500–4,000 sandwich course students a year from sixth forms, provided they had the necessary advanced-level qualifications. Those who had four appropriate passes at ordinary level of General Certificate of Education were eligible to enter directly into the second year of the National Certificate course and could thereby get their Ordinary National Certificate by, say, 18½ and then go either to the university by winning a Technical State Scholarship or to any of the advanced technical college courses. For those who stopped short of the General Certificate of Education or took a different route there was a whole variety of courses.

MANAGEMENT OF SMALL FIRMS

THE difficulties of providing efficient management control in small engineering firms have been analysed by L. Fontaine, J. W. Walker and W. R. Spencer, of Urwick, Orr and Partners; they also make suggestions for introducing and using effective controls*.

In their paper the authors emphasize that, since nearly half of British industrial activity derives from small businesses, it is essential to our economic well-being that they should be well managed. If the manager is the only executive with real management ability, then he is forced to take responsibility for all sides of the business. His company is virtually a 'one-man-band' and its activities are limited to what he can personally achieve in his waking hours each day.

It is a truism that a business cannot stay still; it must either grow larger or smaller. To meet the pressing problems of growth the manager is compelled to bring in (or promote) individuals who are capable of taking over the full responsibility for specific sides of the business. This action immediately causes new organizational problems, and the manager has to readjust his thinking and re-orientate his ideas of how he should run his business. The core of his problem is to build up a management team and to manage his business through them. His task is to set the objectives and to keep watch over the attainment (or otherwise) of these objectives by his subordinates. To many managers of small businesses this can be a most difficult discipline; it is so much easier to continue to do things oneself than to learn how to ensure that others do them instead.

Although management control techniques are no substitute for dynamic leadership, they are, nevertheless, an inescapable part of the mechanisms of modern management. The principles governing these techniques have been tested and proved over and over again. The wise manager of the small business to-day will obtain a clear understanding of these principles before he applies them to specific problems; he will not import 'systems' as such, for they are unlikely to fit and will therefore fail.

The management control techniques considered by the authors are: first, the personal problems arising from the need to delegate responsibility to assistants; secondly, the problems of how to control the design and manufacturing activities; and thirdly, the control of finance and costs and methods of ensuring profitability.

These three separate sets of management control techniques are closely interlinked and each technique is an essential piece in the whole management control pattern. It is possible to introduce isolated control techniques here and there, but the manager who is determined to set his growing business on a continuously successful course will not rest content until he has introduced adequate control over all sides of his business.

* Management Control of Small Engineering Firms. Pp. 39. (London: Institution of Mechanical Engineers, 1958.) 2s. 6d.

THE COMMONWEALTH FUND

THE thirty-ninth annual report of the Commonwealth Fund (pp. xii+41. New York: The Commonwealth Fund, 1957) covers the year ended June 30, 1957, in which 54 grants were voted totalling 3,808,913 dollars, more than 90 per cent being towards the general area of health. The section dealing with medical education and community health, for which 23 grants, totalling 2,009,346 dollars, were voted, of which 11 were new, discusses the close relation and interdependence between social institutions responsible for training health personnel and those institutions and agencies through which health services are made available to the community. Following a review of the Fund's activities by the president, Mr. M. P. Aldrich, the Board decided that for the next few years major emphasis in the health field should remain on medical education; and its interest in community health, in medical research, in nursing and medical fellowships and awards, in related publications and in the programme of international fellowships should continue.

Cornell University received a grant for extending research on care of patients in the Comprehensive Care and Teaching Programme, which embraces both the traditional medical setting and the community and family setting. It should indicate the extent to which, and the manner in which, the application of medical skills is influenced by differing factors in the two environments. The University of Virginia School of Medicine is extending its pilot study of the diagnostic or general clinic as it affects the reorganization of the out-patient department, and the University of Washington School of Nursing received a grant to complete a study of nursing education. Tulane University School of Medicine is studying the personality, emotional and motivational problems of medical students, and a study at the University of Chicago and at Loyola University, Chicago, is designed to develop tests for determining skill in clinical observation, in medical diagnosis and in dealing with professional situations. Grants were also made to the Faculty of Medicine at McGill

University and to the University of British Columbia to enable them to analyse their medical school curricula; to the Georgetown University School of Medicine for revisions of the teaching programme; to the University of Kentucky for the design of a new university medical centre; to the University of Vermont College of Medicine for continued advice to small New England communities on the establishment of appropriate health and medical services. Support of the extended mental health programme of the Rip Van Winkle Clinic was continued, and the New York Academy of Medicine received grants for a study of problems in procuring and distributing whole blood in New York City and for a pilot study of the need and advisability of an intensive study of trends in the future development of medicine.

Medical research received twenty-five grants totalling 815,625 dollars. Nine were for studies of interaction between the organism and its environment, including studies of growth and development, rheumatic fever and arthritis, nine others for neurophysiological and endocrine investigations of integrative processes within the organism and the remaining seven for studies in basic biology, including the porphyrins, the structure and function of nucleic acids and nucleoproteins, the biological role of steroids, histochemical studies of the submicroscopic organization of cells and of extracellular substances, genetic studies of the mechanism of crossing-over and chemical studies of virus formation. A fluid research award was made to assist the intensive research programmes in the Divisions of Chemistry and Biology at the California Institute of Technology.

The report lists nineteen fellowships in the health field and seven other awards in support of creative work, totalling 564,056 dollars, awarded in 1956–57, and also 64 international fellowships for study and travel in the United States. The list includes twenty graduates of universities in the United Kingdom and eleven officers in the Home, Oversea, Australian and New Zealand Civil Services. In the continental programme, eight new awards were made to candidates in Austria, Italy, Switzerland, the Netherlands, Norway and Finland, and twenty-one fellowships received extensions of 3 to 9 months. Under the publications programme, which received a subsidy of 100,000 dollars, six books were issued during the year.

FRAGMENTED HOLDINGS

THE problem of fragmented holdings constitutes a major obstacle to increased agricultural productivity in most of the countries of Europe. The Organization for European Economic Co-operation estimates that 28 million hectares (70,000,000 acres) of agricultural land are broken up into scattered fragments, often only a fraction of an acre in extent. An individual farm holding may often comprise a dozen or more of such fragments. The consolidation of these farms into more manageable and economic units is one of the most urgent needs in efforts to raise living standards among rural people. While this is widely recognized, it is difficult to obtain rapid results because of legal, social and financial difficulties. The four reports* under consideration might suggest that there is an overlapping of effort by the Organization for European Economic Co-operation and the Food and Agriculture Organization, but whereas the Working Party of the latter has a continuing function, the report from the former is the result of a special seminar, held at Wiesbaden during June 27–July 8, 1955. Moreover, there was close collaboration and in several cases the country representatives at Wiesbaden included the members of the Food and Agriculture Organization Working Party. Portugal, which has played a leading part, both with the Food and Agriculture Organization and in practical activities in the country, was not represented at Wiesbaden. In neither case did countries east of the Iron Curtain take part.

The report of the Organization for European Economic Co-operation, which begins with a summary of conclusions, prints nine technical papers which were presented at the seminar, with a brief note of the discussions, followed by summaries of reports from eleven countries and an example of consolidation from Germany.

The problems of fragmented holdings exist in the Republic of Ireland and have been energetically attacked in recent years by the Government through the Irish Land Commission, which is part of the Department of Lands. Subject to right of appeal, the Commissioners have sole power to determine from whom land is to be acquired, the price and, after consolidation, the person to whom the lands are to be allotted and at what price. Consolidation of holdings has, in fact, been part of a transfer from former landlords to tenant purchasers. The problem, as understood in Ireland and in many European countries where it is a burning political question as well as an economic one, scarcely exists in Britain. Powers were given to the British Government under the Agriculture Act of 1947 to deal with land lying idle through having been cut up and sold in plots to prospective house-builders rather than with fragmented agricultural holdings, which in the United Kingdom so often represent a deliberate attempt—unjustified though it may sometimes be—to secure land of different types to make up a balanced holding. The 1940–41 Farm Survey showed the average British whole-time farm to be rather less than 100 acres, or 40 hectares—enormous by comparison with most European countries. The European need is not only to bring fragments of land together within a 'ring fence' but also to secure a minimum area as an economic holding from which the farmer can expect to wrest a modest living. Though the size of a 'viable holding' was discussed at the Lisbon meeting, no conclusions were reached.

The conclusions of the Organization for European Economic Co-operation seminar are in very general terms—the need for an agreed procedure, simplified legal conditions, need for survey, and government financial help; the Food and Agriculture Organization recognizes the need for detailed studies.

* Land Consolidation: Cheaper and More Simplified Methods. (Project No. 199.) Pp. 129. (Paris: European Productivity Agency of the Organization for European Economic Co-operation; London: H.M. Stationery Office, 1957.) 400 French francs; 8s.; 1.25 dollars.
Report of the Working Party of Specialists on the Consolidation of Fragmented Agricultural Holdings, Rome, December 14–18, 1953. (Rome: Food and Agriculture Organization, 1954.)
Report of the First Session of the Working Party on Consolidation of Fragmented Holdings, Sub-Commission on Land and Water Use of the European Commission on Agriculture, held in Lisbon, February 17–18, 1956. Report of the Second Session, held in Vienna, October 1–3, 1957. (Rome: Food and Agriculture Organization, 1957.)

Though the problem differs considerably from one country to another, it may be illustrated from Greece. Out of 1,007,000 farms, only 1,033 exceed 50 hectares (125 acres), whereas 860,304 are less than 5 hectares (12·5 acres). There, rather more than half the land belongs to the farmers, rather less than half to the State, monasteries or a small number of landlords, "whose interest in agriculture is slight or non-existent". Progress in consolidation varies greatly. As the report from Spain says, "the problem has been a matter for discussion for more than 100 years"; despite the urgent necessity, no order was made until December 20, 1952. Now, schemes can be started there either officially or at the request of at least 60 per cent of the farmers affected. It is interesting to note that even in the short time since the passing of the order, 257 villages covering 385,000 hectares and affecting 40,000 farmers have applied. Although France is not so badly affected, a law of March 9, 1941, had led by October 1954 to 4,910 schemes affecting 3,600,000 hectares out of a total of 50,500,000 of the agricultural area of the country. In general, it would seem that with varying speed the needed agricultural revolution is taking place. But it would also seem that the owner-occupier small-holding is being made the ideal; peasant-proprietors are replacing landlord and tenant. Consolidation into large holdings of several hundred acres, which technologists claim as the most efficient economically, remains almost unknown. L. Dudley Stamp

SIZE DIFFERENCES IN *CUCURBITA*

SIZE differences have been studied by K. E. von Maltzahn (*Canad. J. Bot.*, 35, 809, 831; 1957) in vegetative organs of two pure-bred strains of *Cucurbita pepo* L. which differ greatly in size by their genotype. The growth pattern of plants of the selected strains was found to be essentially the same in the two types. The two strains exhibited great differences in mature organ size, but only small differences in number of organs. No correlation was found between embryo size and mature size. In the early stages of primary shoot development, however, a correlation was found between embryo size and the rate of initiation of new organs. This correlation disappeared during the later stages of plant development. The parental strains had similar rates of organ formation, while the crosses showed hybrid vigour with respect to rate of new organ formation. Sizes of the apical meristems and organ primordia were essentially the same in the large and small strains and did not appear to determine mature organ size differences.

Development of size differences between the same organs of the two strains and the crosses was found to be mainly due to duration of organ growth. Rates of organ growth differed only slightly between the strains. Increase in size of successively formed organs of the same strain was also found to be mainly due to duration rather than to rate of organ growth. Mature organ size has been analysed for the two strains on the histological and cellular levels with particular emphasis on mature internode size. Differences between the strains in tissue and cell size were observed for the main tissue and cell types. Differences in internode length were determined both by differences in cell size and cell numbers. Cambial activity as expressed in numbers of radial immature derivatives and in number of divisions in the inter-fascicular regions was found to be much greater in strain *CF* than in *SRC*.

No important differences were found between the large and small strain in the size of the meristematic and submeristematic regions. Early internode growth in terms of cell division and cell enlargement was also found to be similar in the two strains. It is concluded that the cellular differences found in the mature organ must be due to a longer duration of growth mainly in terms of cell enlargement but also in terms of cell division. This conclusion is supported by the results obtained on internode growth described in a previous paper. Grafting experiments with apical buds of the two strains did not show any influence of the stock on the scion; mature organ size was determined only by the scion.

THE SEA OTTER

AN account of the sea otter has been given by Karl W. Kenyon of the United States Fish and Wild Life Service (*Oryx*, 4, No. 3; November 1957).

In general form the sea otter, *Enhydra lutris*, resembles the weasel and river otter, but is larger in size. The male attains a weight of 85 pounds, the female about 65 pounds; the young at birth weigh 3–5 pounds. It is peculiar among members of its family, the Mustelidae, in having deserted dry land and fresh-water to take up a marine life. Among marine mammals it is peculiar in its adaptation to the sea. It does not possess an insulating layer of blubber but is protected from the chill of the North Pacific waters by a blanket of air trapped among the fine and closely packed fibres of its inch-long, delicate fur. Unlike the river otter and fur seal, the sea otter has but little protective coating of guard hair. The fine guard hairs present add to its beauty but do not offer much protection to the under-fur. Unlike other marine mammals, the sea otter has never taken to the open sea. It usually feeds in shallow water from 5 to 50 ft. in depth. Its food consists primarily of such sedentary forms as sea urchins, rock oysters, mussels, a variety of snail-like molluscs and, in California, abalones. Occasionally fish and octopus are eaten.

Although the sea otter is not ideally adapted to its marine environment, it is far more at ease in the water than ashore. The flipper-like hind feet are clumsy on land and the long flexible body is poorly suited to walking. When otters haul out to sleep or preen, they seldom venture more than a few feet from the water.

Otters come ashore in greatest numbers when storm waves make food-diving difficult. When the weather is calm they usually sleep on the surface of the sea, simply pulling a strand of kelp over their bodies, resting the head on the chest and placing their forepaws over their eyes.

In the Aleutian Islands at least, the breeding season of the sea otter is not well defined. Most pups are

born in April or May but newly born young are to be seen at other seasons. Mating takes place in the water and the mated pair may remain together for several days.

Like other marine mammals the sea otter bears but one pup at a time but, unlike most of them, the mother otter gives her offspring constant and careful attention over a relatively long period, probably until it is nearly a year old. For several months the pup receives most of its nourishment from its mother's two abdominal nipples, though at an early age it may also beg for and receive parts of sea urchins and molluscs that its mother is eating. She carries her pup on her chest while she herself swims on her back.

When the ships of Captain Cook dropped anchor at Macao after having visited Nootka Sound, Vancouver Island, the crews discovered that skins which they were using as bed clothing and garments, and which they had purchased cheaply from the Indians, were worth thousands of dollars. Thereafter, the soft fur of the sea otter was the objective of many of those who explored the coast and islands of the eastern North Pacific Ocean.

Under the direction of white fur-hunters, sea otters were mercilessly pursued, sometimes by teams of Indians in canoes; in more remote areas by white hunters in light skiffs carried to the otter grounds in larger ships. So highly was the sea otter prized that by the end of the nineteenth century it had been hunted almost to extinction. The otters living off the western coasts of the United States were thought to be extinct. Even yet none has been found on the coasts of Oregon or Washington, but in 1938 a group of 94 sea otters was discovered near Monterey, California. Now the Californian otters are said to number about five hundred, living under complete protection.

In 1786, the Pribilof Islands were discovered by Russian fur hunters and their history shows similar thoughtless exploitation. In the first year of occupation as many as five thousand sea otters were killed. By 1811 they were scarce animals and during the next thirty years were virtually exterminated. The last recorded skin in the Pribilofs was taken from an otter found dead in 1892. Of this once thriving colony only scattered bones remain.

RADIAL VELOCITIES OF SOUTHERN *B* STARS

A SECOND paper, with the title "Radial Velocities of Southern *B* Stars", by M. W. Feast, A. D. Thackeray and A. J. Wesselink, of the Radcliffe Observatory, appears in *Mem. Roy. Astro. Soc.* (**68**, Part 1). The observations are the second stage in the determination of radial velocities of southern *O* and *B* type stars at the Radcliffe Observatory, Pretoria. In the first stage, the 147 stars were of magnitude 7·5 or brighter and with spectral type *B*5 or earlier, but in the second stage much fainter stars were observed and every effort was made to select the most distant stars available. Oosterhoff's photoelectric observations (*Bull. Astro. Inst. Neth.*, **2**, 299; 1951) were utilized and the initial programme consisted of all stars for which this list gave a corrected distance modulus $m_0 - M \geqslant 11{\cdot}0$. This selection accounts for about 75 per cent of the 130 stars considered. Greater average distances than those in the authors' first paper are ensured by the fact that all Oosterhoff's stars had *HD* types B_2 or earlier, with a few Wolf Rayet stars. Another important fact is that the criterion $m_0 - M \geqslant 11{\cdot}0$, which was based on photoelectric colours and *HD* types, provides fairly good evidence that faintness is due to distance rather than to obscuration. The observing list is extended by the addition of a number of stars recently classified as *O* or *B* supergiants, and a few of special interest in the Carina region.

The instrument used was the 2-prism Cassegrain spectrograph attached to the Radcliffe 74-in. reflector. The faint stars catalogued in the paper demanded the use of a fast emulsion, and while this had probably little effect on the accuracy of the mean velocities, nevertheless the poor line stars were often difficult to measure, in spite of the wider trailing of the spectra. The standard slit-width for the *c* camera was 0·075 mm. and for the *b* camera 0·050 mm.

Other matters that are referred to include standard wave-lengths, contributors to programme, and observations. Under the latter it is pointed out that the velocities are being analysed for galactic rotation and the results will be published later. The preliminary investigations indicate that the fainter stars must be at a mean distance about $2\frac{1}{2}$ times that of those in the first paper, and in consequence the analysis will be obliged to take into account second-order effects.

AN EXPERIMENT ON THE INTERACTION BETWEEN A PLANE SHOCK AND A MAGNETIC FIELD

By Dr. K. DOLDER and Dr. R. HIDE*
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THIS is a preliminary report of an experimental investigation of the hydromagnetic interaction between rapidly moving, hot, ionized (and therefore conducting) gas and an intense magnetic field. The experiment has two essential features. First, the gas flow is so rapid that dynamical effects of compressibility are present; and secondly, the system has axial symmetry.

When a fluid of density ρ, permeability μ and electrical conductivity σ moves relative to a magnetic field of strength B, electrical currents are induced. It may be shown on general theoretical grounds that unless the dimensionless parameter

$$R_1 \equiv 4\pi L U \sigma \mu \qquad (1)$$

is small compared with unity (where L is a length characteristic of the scale of the system and U is a typical flow velocity), these currents will seriously

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modify the initial magnetic field. Furthermore, if a second parameter,

$$R_2 \equiv BL\sigma(4\pi\mu/\rho)^{\frac{1}{2}} \qquad (2)$$

is sufficiently large the ponderomotive forces associated with these currents will modify the initial fluid flow[1]. These so-called hydromagnetic effects, though common in cosmical physics owing to the vast dimensions involved[2], are not easily produced in the laboratory.

We have observed strong hydromagnetic interaction when R_2 (suitably defined, see below) exceeds about 0·4, the highest value attained in our experiments being 1·52. In other laboratory systems (notably high-current electrical discharges in gases) R_2 can exceed 10^3, but these systems are dynamically complex[3]. Several hydromagnetic experiments in liquid metals have been reported[4], although compressibility effects do not then arise.

Our apparatus consisted of a combustion-driven shock tube (Fig. 1) in which argon, initially at rest and at room temperature, was accelerated to a high velocity ($\sim 4 \times 10^5$ cm./sec.) and heated by compression to more than 10,000° K. Thermal ionization rendered the gas conducting ($\sigma \sim 10^{-7}$ E.M.U.).

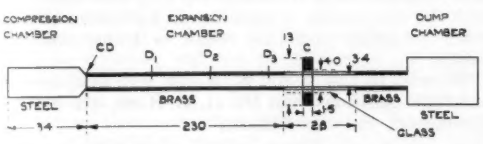

Fig. 1. Diagrammatic view of shock tube (Not to scale. Dimensions in centimetres)

The compression wave which heated and accelerated the argon gas was generated when the copper diaphragm (CD) was burst by the combustion of a mixture of hydrogen and oxygen in the compression chamber. This wave rapidly built up into a shock moving at M times (say) the speed of sound in the undisturbed gas ahead of the shock. M was determined in each experiment by measuring the time taken by the shock to pass between detector stations D_2 and D_3.

The object of the experiment was to study the interaction of this high-speed gas flow in the shock with a magnetic field, produced by a circular coil C. The magnetic field strength at the centre of the coil, B_c (say) corresponding to the highest attainable current in the coil (2,600 amp.), was 3×10^4 gauss. This current was supplied by discharging a condenser through the coil by means of an ignitron switch. Although this current was transient, lasting only 10^{-3} sec., synchronization by means of trigger and delay circuits, actuated by the electrical signal from the detector station D_1 when the shock passed, ensured that during the 5×10^{-5} sec. or so that shock moved through the coil, the magnetic field was substantially steady.

The hot gas was brilliantly luminous, and this light was visible through the glass observation section of the expansion chamber.

Table 1

Shock Mach number (M)		16·9	16·9	17·8
Initial argon pressure in expansion chamber (cm. of mercury)	p_1	2·5	5·0	0·1
Density of gas behind shock (gm. cm.$^{-3}$)	ρ_2	$4·3 \times 10^{-4}$	$8·3 \times 10^{-4}$	$2·2 \times 10^{-5}$
Temperature of gas behind shock (deg. K.)	T_2	15,450	15,000	12,900
Speed of gas behind shock (cm. sec.$^{-1}$)	u_2	$4·7 \times 10^5$	$4·5 \times 10^5$	$5·1 \times 10^5$
Conductivity of gas behind shock (E.M.U.)	σ	9×10^{-3}	9×10^{-3}	$6·7 \times 10^{-3}$
—	R_1	0·53	0·51	0·43

The purpose of the steel dump chamber was to absorb the energy of the shock, thus protecting the glass section from the high pressure associated with the reflected shock which would otherwise have been generated.

The pattern of light emitted by the hot gas was recorded photographically by a camera which was left open for the duration of each experiment.

The data appropriate to the experiments are listed in Table 1. In each case from the measured value of M, the density ρ_2, temperature T_2 and flow velocity u_2 of the shocked gas were deduced by means of standard shock theory, corrected for the effect of ionization on the specific heat. The electrical conductivity σ was taken from the data of Lin, Resler and Kantrowitz[6]. 1·0 cm., the order of the dimensions of the coil, and u_2, the gas flow velocity, were taken as appropriate values of L and U, respectively, in estimating R_1 (see equation 1).

The results of five experiments corresponding to different combinations of the initial argon pressure, p_1 (which is at constant temperature simply proportional to the initial density ρ_1), M, and B_c are given in Table 2. The range of R_1 covered is small (0·43–0·53). R_2 (see equation 2), calculated by taking $\rho = \rho_2$ and $B = B_c$, was varied from 0 to 1·52. When $R_2 = 0$ (no magnetic field) the pattern of luminosity is as shown in Fig. 2. However, when $R_2 = 1·52$ (experiment 3) the luminosity pattern is quite different (see Fig. 3). Immediately upstream of the coil there is a definite increase in light intensity, and downstream a characteristic pattern is seen. This pattern was observed in experiments 2 and 5, corresponding to $R_2 = 0·46$ and $R_2 = 0·45$, respectively, and did not arise in experiments 1 and 4 for which $R_2 = 0·33$. The range of ρ_2 covered by these

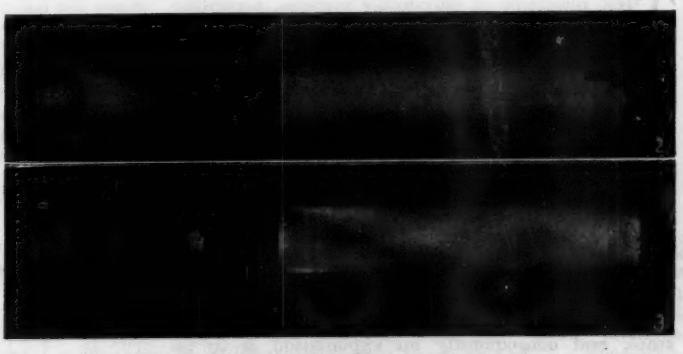

Fig. 2. Light emitted from shock tube when $R_2 = 0$
Fig. 3. Light emitted from shock tube when $R_2 = 1·52$

Table 2

Experiment No.	Shock Mach number M	Initial argon pressure p_1 (cm. Hg)	Field at centre of coil B_c (gauss)	R_1	R_2	Luminosity pattern
1	17·8	0·1	6,600	0·43	0·33	As Fig. 2
2	17·8	0·1	9,000	0·43	0·46	As Fig. 3
3	17·8	0·1	29,700	0·43	1·52	As Fig. 3
4	16·9	5·0	29,700	0·51	0·33	As Fig. 2
5	16·9	2·5	29,700	0·53	0·45	As Fig. 3

experiments is sufficiently large for the tentative conclusion to be drawn that R_2 (see equation 2) is the appropriate parameter in terms of which the magnetic field strength should be measured. It has been inferred from the foregoing results that significant hydromagnetic effects arise when R_2 exceeds about 0·4.

Although these results demonstrate the significance of the parameter R_2, it is too early at present to attempt a full interpretation of them. This must await the results of time-resolved measurements and an investigation of the magnetic effects of the induced currents. However, it is instructive to consider the initial stage of the interaction.

Take cylindrical co-ordinates (r, θ, z) with the z-axis coincident with the tube axis. Well upstream of the coil the flow velocity is:

$$\mathbf{u} = (0, 0, u_z) \tag{3}$$

The magnetic field of the coil is:

$$\mathbf{B} = (B_r, 0, B_z) \tag{4}$$

so that the electromotive force,

$$\mathbf{E} = (0, u_z B_r, 0) \tag{5}$$

is induced. If $u_z = 4 \times 10^6$ cm./sec. and $B_r = 10^4$ gauss then $u_z B_r = 40$ volts/cm. and, owing to the geometry of this system, this electromotive force cannot be balanced by any charge distribution on the walls of the tube. Hence an electric current of density

$$\mathbf{j} = (0, \sigma u_z B_r, 0) \tag{6}$$

must flow. If $\sigma = 10^{-7}$ E.M.U. then the strength of this current is 4,000 amp./cm.^{2}. Presumably the heating due to this current will cause additional luminosity.

The ponderomotive force per unit volume, **F**, due to the interaction between **j** and the field **B** of the coil has two components,

$$F_r = -\sigma u_z B_r B_z, \text{ and } F_z = -\sigma u_z B_r^2 \tag{7}$$

typical values of which are of the order of 10^6 dynes/cm.^{3}.

F_z tends to retard the initial flow and F_r tends to accelerate the gas towards the axis or, in other words, the gas tries to follow the lines of force[2]. The increased luminosity at points near the axis downstream of the coil may be associated tentatively with radial oscillations initiated by F_r as the moving gas leaves the proximity of the coil.

The characteristic light pattern of Fig. 3 could not be produced when the initial pressure p_1 was less than 0·075 cm. mercury ($M \approx 16$) even though values of B_c up to 30,000 gauss were used. This may be a consequence of the relatively long time associated with the attainment of equilibrium ionization at these lower densities, and this result is being examined further.

We wish to thank Mr. W. Millar, who made several helpful suggestions, and Mr. G. H. Hirst, who assisted throughout the experiments.

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PLASTICITY OF CLAY-WATER SYSTEMS

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THE plasticity of clay-water systems, according to Macey[1], is due to the network of surface repulsive forces between the clay particles set up when a small amount of water is present. Each particle takes up a position of equilibrium in which the forces between it and its neighbours balance. Application of an external force produces deformation by moving the particles over one another; on its removal the deformed shape is retained due to existence of another network of forces. According to Norton[2], the clay particles in a plastic mass are always acted upon by two forces in equilibrium, namely, a repulsion between the particles, and a compressive capillary force due to the water film on the surface of the mass.

Plasticity is, however, a property of the solid state, and consequently an explanation is to be sought in the plastic behaviour of the solids present. Since the individual clay particles do not themselves exhibit the behaviour of a clay-water system, an explanation of the plasticity of such systems is proposed in terms of the plasticity of soft 'ice'-crystals formed on the surface of the clay particles.

Norton[2] gives a typical stress-strain diagram for plastic clay from which one can form an approximate estimate of the values of shear stress, strain and modulus, just before plastic deformation begins (Table 1).

Table 1

Percentage water	Shear stress (dynes/cm.^{2})	Shear strain	Shear modulus G	Thickness of ordered layer (A.)
35	$9{\cdot}2 \times 10^5$	0·062	$14{\cdot}8 \times 10^6$	18·0
40	$4{\cdot}9 \times 10^5$	0·056	$8{\cdot}75 \times 10^6$	20·0
50	$1{\cdot}5 \times 10^5$	0·041	$3{\cdot}66 \times 10^6$	27·5

The critical shear stress changes with water content and is of the order of 10^5–10^6 dynes/cm.^{2}.

The yield strength of the softest crystals is likely to be of the order[4] of $10^{-5}\mu$, where μ is the shear modulus for an ordinary crystal. For polycrystalline ice[5], $\mu \simeq 10^{10}$ dynes/cm.^{2}. Thus if the plastic behaviour of the clay-water system is assumed to be due to plastic deformation of very soft ice-crystals formed in such systems, the order of the observed shear stress can be explained. This explanation of plastic deformation of such systems is in accord with the dislocation theory of plasticity of crystalline solids.

It is generally agreed that in the clay-water system there is a layer of water rigidly attached to (001) faces of clay particles, with ordered arrangement of molecules in it, having the structure of ice[1] with the basal plane parallel to the (001) plane of clay. The thickness of the ordered layer which forms the periphery of the water-film separating the clay particles is estimated[6] to be about 25 A. Thickness of the water-film is taken to be about 1000 A., though it need not be assumed that the separation of clay particles is invariably complete or that all the water films are of the same thickness[7]. It can thus be taken that there may be regions where clay particles are separated by an ordered layer of water with ice-like structure.

There is good evidence for the presence of dislocations in crystals, and the possibility of ice crystals having such low strengths is due to the presence of dislocations in them. The critical shear stress, σ, needed to move an edge dislocation of unit length which is parallel to rows of atoms in the slip plane is given by[4]:

$$\sigma = \frac{2\mu}{(1-\nu)} \exp\{-2\pi a/b(1-\nu)\} \qquad (1)$$

where μ is the shear modulus of an ordinary crystal, ν is Poisson's ratio, a is the distance between glide planes and b is the interatomic distance in the direction of slip. In the case of ice, $\mu = 3{\cdot}2 \times 10^{10}$ dynes/cm.^{2}, $\nu = 0{\cdot}34$, $a = d_{0001} = 3{\cdot}68$ A., $b = 4{\cdot}52$ A., being the interatomic distance in the slip direction $<2\bar{1}\bar{1}0>$ (of hexagonal ice) in the basal plane. Thus from equation (1), $\sigma = 4{\cdot}2 \times 10^7$ dynes/cm.^{2}. This value is still one hundred times greater than those given in Table 1. In actual specimens it may be further reduced by several orders of magnitude due to the presence of wider or zigzag dislocations[4]. The critical shear stress may thus be taken to be of the order of 10^5 dynes/cm.^{2}. Precise values cannot be calculated without detailed knowledge regarding dislocations.

Some authors have failed to find an elastic region in clay-water systems, implying that the critical shear stress has become very low. On the present point of view this means that the structure of the adsorbed layer has become so defective that its behaviour is more like that of liquid water than of crystalline ice, so that there is no measurable shear stress. In such cases the critical shear stress can be raised by stabilizing the lattice of the adsorbed layer of water, as, for example, by adding ions having dimensions comparable with those of water molecules. Obviously these ions should not disturb the hydrogen bond.

The shear modulus of an ice crystal of thickness t formed between two clay particles can be calculated. If σ is the critical shear stress necessary to slip one part of the crystal with respect to another through the smallest possible amount λ, then for stable slip to occur[8]:

$$\sigma = \frac{G\lambda}{2t} \qquad (2)$$

where G is the shear modulus of soft crystal. Taking σ to be of the order of 10^5 dynes/cm.^{2} and λ, the interatomic distance along the observed direction of slip, in case of ice as 4·52 A., and t as 50 A., we find $G = 2{\cdot}2 \times 10^6$ dynes/cm.^{2}. This is of the same order as the values given in column 4 of Table 1.

Using the values of shear stresses and shear moduli given in Table 1, the thicknesses of the ordered layer of water on clay particles for different percentages of water can be obtained from equation 2 and are given in column 5. The values are close to estimates made from other considerations[6], applicable when the adsorbed layer retains crystalline order.

I wish to thank Lt.-Gen. Sir H. Williams, director, and Dr. N. K. Patwardhan, assistant director, Central Building Research Institute, for their interest in the work.

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CULTIVATION AND DEVELOPMENT OF LARVAL CESTODE FRAGMENTS *IN VITRO*

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AXENIC culture of parasitic helminths presents a number of well-recognized problems, chief of which are: (*a*) establishment and maintenance of aseptic conditions; (*b*) provision of a medium with physical characteristics (osmotic pressure, oxygen tension, viscosity, *p*H and temperature), simulating those of the host environment; (*c*) provision of food materials, presented in a form capable of being utilized by the parasite, and sufficient to satisfy the nutritional requirements of growth and maturation; (*d*) provision of cultural conditions permitting rapid removal of inhibiting metabolic waste products from the immediate vicinity of a developing worm.

Culture of cestodes presents special difficulties not encountered with other groups of helminths, due to the relatively great size and elongated shape of the strobila, and its exceptionally high rate of growth. *In vivo*, a strobila lies closely apposed to the intestinal wall, its length and tape-like shape assisting it in maintaining this position. Due to the comparative freedom within a culture vessel as compared with the gut, however, worms *in vitro* show a tendency to tie themselves in knots—an action which results in cytological degeneration at the site of the knotting and subsequent abnormal development. The large size also implies that the volume of medium necessary for successful culture is likely to be considerable, and provision of this becomes acute when culture of cestodes many yards long—such as *Diphyllobothrium latum*—is contemplated.

These problems as they relate to pseudophyllidean cestodes have recently been broadly reviewed[1]. The avian forms *Schistocephalus solidus* and *Ligula intestinalis*, the plerocercoid larvæ of which occur in the body cavity of fish, are the only pseudophyllidean cestodes readily matured *in vitro*. These are unusual cestodes with broad larvæ which do not knot readily and which are rich in food reserves and possess genital primordia in the organogeny stage of development (Fig. 1). Thus, once the problems of maintaining asepsis, providing a suitable environment, and eliminating waste materials are overcome, maturation *in vitro* presents little difficulty. In these cases, the culture medium merely provides an environment with suitable physico-chemical characteristics and supplies nothing in the way of nutrient materials. In the case of *Schistocephalus*, provided cultivation is carried out within cellulose tubing to assure fertilization, and the cultures agitated to assist in the elimination of toxic waste products, the remaining maturation stages are rapidly reached, and eggs with up to 88 per cent fertility[2] may be obtained[3,4]. Coracidia hatched from eggs obtained *in vitro* have been carried through their developmental stages in *Cyclops* and fish, respectively, and the resultant plerocercoids again matured *in vitro*, so that the life-cycle has now been completed without the use of a definitive warm-blooded host[3].

The majority of cestodes, however, have larval forms which are both relatively undeveloped morphologically and poor in food reserves, so that considerable tissue synthesis and differentiation must take place before maturation is achieved. To provide materials for growth of this order is clearly a problem of some magnitude in the case of large cestodes. The avian form *Diphyllobothrium dendriticum* has plerocercoids of this type which are readily obtained from fish, and serves as excellent experimental material.

Life-Cycle of *Diphyllobothrium dendriticum*

The life-cycle follows the typical pattern of the Diphyllobothriidae with copepods and fish as intermediate hosts, and birds as definitive hosts. Rats act as convenient laboratory hosts[4,5] and maturation *in vivo* requires only 6–7 days—a time-range which brings the organism within the range of possible *in vitro* culture. By autopsying rats fed with plerocercoids at 24-hourly intervals, and making suitable morphological and histochemical preparations[6], it is possible to build up a picture of *in vivo* development with which development *in vitro* can be compared. Maturation can be conveniently divided into the following seven phases, which represent approximately the degree of morphological development attained on successive days during the 7-day period of maturation in a rat (Fig. 1): (1) cell multiplication; (2) segmentation; (3) organogeny; (4) early gametogeny; (5) late gametogeny; (6) egg-shell formation; (7) oviposition.

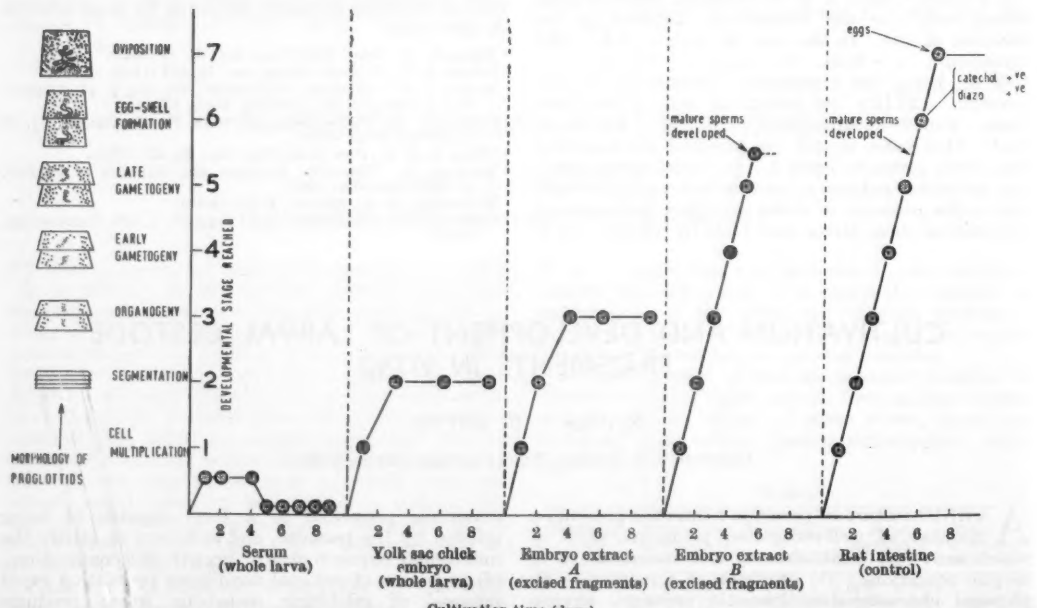

Fig. 1. Comparative development of whole plerocercoids or excised fragments *in vitro* and *in vivo* of *Diphyllobothrium dendriticum*

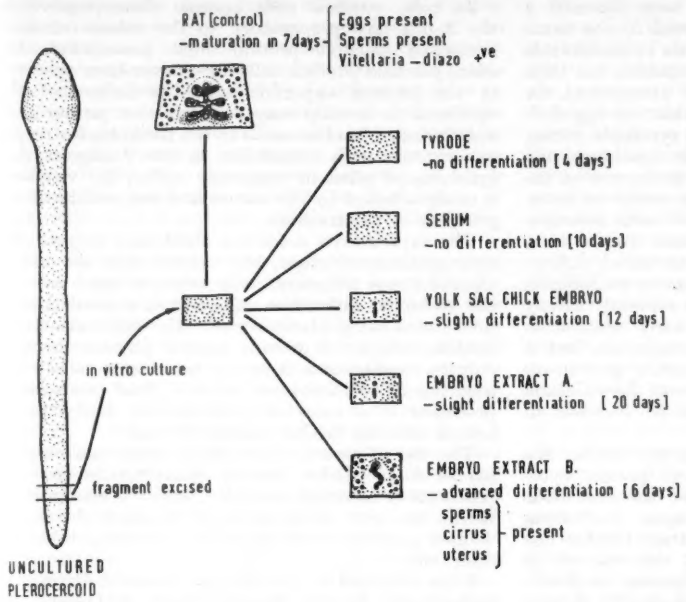

Fig. 2. Fate of excised plerocercoid fragments of *Diphyllobothrium dendriticum* in different media. Not to scale. Details as in Fig. 1

It is important to develop precise criteria for the recognition of each of these phases so that the degree of development taking place in any medium can be evaluated. A number of cytological or histochemical criteria have been established[7], of which estimation of mitotic activity by colchicine inhibition[8] has been perhaps the most useful for the early stages. The growth-producing powers of a medium can be assessed after 24-hr. culture, thus avoiding the prolongation of unsuccessful experiments.

Experiments with Whole Plerocercoids

Preliminary experiments were carried out using saline or serum as a basic medium reinforced with nutrients such as glucose, meat extracts, yeast extracts or tissue extracts. Attempts were also made to develop plerocercoids in the amnion or yolk sac of a chick embryo. These experiments, begun in 1947[9], have extended over a number of years, and have been almost entirely unsuccessful. Some differentiation was obtained in the amnion or yolk sac or in dilute embryo extract, and stages 2 or 3 (Fig. 1) were reached. The time required for this degree of differentiation, however, was 10–20 days—a period more than twice that required (7 days) for maturation normally to be achieved *in vivo*. All these early experiments suffered from the disadvantage already stressed, that worms tended to tie themselves in knots, with subsequent abnormal development. Attempts to overcome this difficulty by culturing within cellulose tubing, as used for *Schistocephalus*, and by various other means were not successful, and it was felt that little progress would be made until this problem was overcome. Efforts have now been made to eliminate this difficulty by culturing small excised fragments of plerocercoids instead of entire larvæ, and the results of this approach are considered here.

Experiments with Plerocercoid Fragments

Plerocercoids were removed aseptically from fish and fragments 1–2 mm. long cut from the posterior quarter of the larvæ (Fig. 2). These were cultured at 40° C. in (*a*) 30 mm. Carrel flasks (at rest) or (*b*) 20 ml. screw-top vials (shaken continuously about 100 times per minute). The degree of maturation obtained in these fragments surpassed any previously achieved with whole worms in any medium. In dilute duck embryo extract (Ext. *A*: 2 gm. tissue per 10 ml. Tyrode) fragments became segmented and developed traces of genital anlagen (stage 3, Fig. 1) but did not undergo further development, although surviving for periods up to 20 days. Using more concentrated extract (Ext. *B*: 4 gm. tissue per 10 ml.) in shaken vials, fragments became segmented by the second day, developed genital anlagen by the third day (stage 3) and by the sixth day had become differentiated into recognizable proglottids containing a cirrus and a cirrus sac, coiled uterus and testes capsules—development corresponding to stage 5 in Fig. 1. Aceto-orcein squashes revealed the presence of mature spermatozoa in the testes in the most successful experiments. Cells representing the primordia of the ovaries or vitellaria were not detected. The testes appeared to be especially sensitive to abnormal conditions of cultivation, and in many cultures underwent degeneration without further differentiation. This sensitivity of the testes to abnormal cultivation conditions is well known in both cestodes[10] and trematodes[11] and acts as a useful criterion for 'normality' of behaviour.

A striking feature of the development of these fragments was the fact that although an advanced state of differentiation was reached, virtually no cytoplasmic growth took place in the tissues. The result was that the fragment gave rise only to 'miniature' proglottids (Fig. 3) each estimated to be about 1/5–1/10 of the size of those matured in a rat. Maturation beyond this point has not been achieved; further cultivation resulted in the sudden onset of autolysis on the 7–8th day of culture.

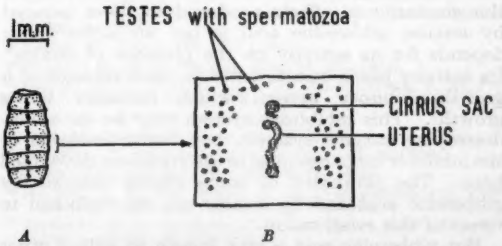

Fig. 3. *A*, scale drawing of mature fragments after six days culture in concentrated embryo extract, showing differentiation into 'miniature' proglottids; *B*, diagram of proglottid showing degree of development

These experiments, which have been repeated a number of times, have all terminated in the same way, that is, by the sudden autolysis of proglottids after an advanced stage of spermatogenesis has been reached. This result is perhaps not unexpected, for the next stage of development, that of egg-shell formation, is one of intense protein synthesis during which the cells of the vitellaria are manufacturing the necessary protein and phenolic precursors of the egg-shell[7,8]. The onset of autolysis could be interpreted as being due to the embryonic tissue attempting to satisfy its excessive nutritional requirements at the expense of its own cells. Concentrated embryo extract, used as a medium, as well as its well-known property of stimulating mitoses, can evidently satisfy the nutritional requirements of the early maturation stages up to and including spermatogenesis, but it does not permit extensive cytoplasmic growth to take place, as witnessed by the failure of the vitellaria to mature, and of the proglottids to increase in size.

The problem then remains to increase further the nutritional value of the medium to permit cytoplasmic growth and to provide for the enormous demands of the final maturation stages. Increasing the concentration of the embryo extract further has been found to be inhibitory, and the relation of concentration to growth-response appears to follow the pattern found in tissue culture studies[12]. Mitotic stimulants appear not to be lacking, for the rate of mitoses achieved *in vitro* has been higher than that found *in vivo*. Other nutritional factors must be involved, the nature of which is at present unknown, but are likely to be essentially amino-acids and monosaccharides—breakdown products of proteins and carbohydrates normally available in the vertebrate intestine. Other factors, too, may be important, and the likelihood that organizers are involved at some stage must also be considered, although the results suggest that the fate of at least the posterior region of the proglottids is clearly determined in the plerocercoid stage.

In vivo, vitelline cells become diazo-positive on the 5–6th day preparatory to the release of their contained phenolic–protein shell precursors[7], but diazo-positive vitelline cells have never been observed in the present experiments. The failure of the vitellaria to develop may be suggestive primarily of a deficiency of amino-acids in the medium, for recent experiments with trematodes *in vitro*[13] suggest that synthesis of phenolic materials within the vitellaria is easily affected by the nature and availability of the proteins in the medium.

The experiments described above are, as yet, at a very preliminary stage, but suggest that the use of excised tissue fragments overcomes at least some of the technical difficulties inherent in normal culture procedures using whole worms. The elaboration of a medium which will provide suitable physico-chemical culture conditions and at the same time satisfy the nutritional requirements of the final maturation processes is a complex problem not likely to be solved without further extensive work.

The use of media of biological origin can only be expected to make limited contributions to the problems of helminth nutrition, and the introduction within the near future of methods using chemically defined media to investigate these problems is clearly desirable.

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ROLE OF GIBBERELLIN-LIKE HORMONES IN REGULATION OF PLANT GROWTH AND FLOWERING

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THE most obvious response of plants to gibberellic acid is increased shoot growth in which increases of size of both stem and leaves may be involved. This is mainly a result of cell extension. Despite this similarity in effects produced to those induced by auxins, gibberellic acid is not an auxin[1,2] but depends for its activity on the presence of auxins[3]. Its activity has been attributed to neutralization of a growth-inhibitory system which normally limits growth[4]. This inhibitory system may be an auxin-destroying enzyme system[5], but characterization of the inhibitor is not essential to the argument developed here. The similarity of some effects induced by gibberellic acid and by auxins can be explained in terms of this relationship.

But gibberellic acid is now known to induce other physiological responses. These include: (*a*) breaking of dormancy of light-sensitive seeds[6,7]; (*b*) prevention of arrested fruit growth of some varieties of tomato[8]; (*c*) induction of flowering of long-day plants grown in short-day photoperiods[9]; (*d*) inhibition of flowering of short-day plants grown in inductive short-day photoperiods[10]; (*e*) inhibition of tuber-formation of potatoes despite increased top growth[11]; (*f*) decreased tillering of cereals[12]; (*g*) breaking of epicotyl dormancy of tree pæonies[13]; (*h*) reversal of physiological dwarfing of *Malus* spp. associated with the use of non-after-ripened seed[14]; and (*i*) induction of stem formation in biennials kept in temperatures above the threshold for vernalization[9]. In effects *a–f* inclusive gibberellic acid simulates light; effects *c–f* are typical responses to long-day photoperiods. In effects *g–i* it simulates exposure to low temperature. Thus there is an underlying physiological unity in these responses, strengthened by a similarity in action spectrum in the light-induced responses, red light

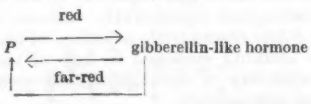
(650 mμ) usually being most effective. A further common characteristic is the reversibility of the photoreaction, a response to red light being reversed by a subsequent exposure to far-red (730 mμ), this effect in turn being reversed by a further exposure to red, and so on. The striking similarity of the effects of red light and gibberellic acid is not seriously diminished by certain differences, for example, the failure of light to reverse genetic dwarfing, which is reversed by gibberellic acid[15,16], or the failure of gibberellic acid to simulate certain growth-inhibiting effects of red light[17,18].

The significance of these observations is increased by the discovery that gibberellin-like hormones, for long known only as fungal metabolic products, also occur in higher plants. Their existence in plants was suspected[19,20] when it was found that genetic dwarfs in several plant species could be induced to assume the form of the normal tall phenotype when treated with gibberellic acid, auxins being ineffective[15,16]. Using the response of genetic dwarfs as a bioassay, gibberellin-like hormones have been found in seeds of several plant species[21,22], in shoots and roots of pea seedlings[19,22], and in young inflorescences of *Brassica napus*[23]. Chemical relationship to gibberellic acid of one of these hormones has been demonstrated by the isolation of gibberellin A_1, a dihydro-derivative of gibberellic acid, from runner-bean seed by MacMillan and Suter[24]. Since such hormones occur in plants, and since gibberellic acid has been shown to intervene in so many light-controlled stages of plant development, it seems virtually certain that these natural gibberellin-like hormones are involved in light-induced physiological responses.

Photoperiodic responses of plants can be explained by the following scheme. In response to light, gibberellin-like hormones are formed in leaves, a physiologically inactive (or less active) precursor (P) being an intermediary :

$$CO_2 \longrightarrow P \longrightarrow \text{gibberellin-like hormone}$$

The hormone is converted slowly back to P in darkness, and, more rapidly, if the leaf is exposed to far-red light. If the leaf is then exposed to red light once more, the hormone is again formed from P. Thus in long-day conditions increasing concentrations of the hormone will be built up but in short-days concentrations will be much lower. Thus, if it is supposed that high levels of gibberellin-like hormone induce flowering in long-day plants but that flowering takes place in short-day plants only when levels of the hormone are low, the response of these plants to light and to exogenous gibberellic acid is explained.



The scheme has the further advantage that it accounts for the general association of shoot extension with flowering in long-day plants, and for the dwarfed appearance of many short-day plants in inductive short days and their far greater vegetative development in long days (shown particularly well in *Kalanchoe*[25] and soy-bean[26]). Day neutral plants can be regarded as plants independent of light for biosynthesis of gibberellin-like hormones, a view supported by the detection of such hormones in etiolated pea tissues[22].

The effects of gibberellic acid and light on germination of light-sensitive seeds can similarly be understood if we assume that during maturation of the seed gibberellin-like hormones are converted to the precursor P; treatment with red light after imbibition leads to reconstitution of the hormone and germination can proceed, as is also possible in darkness if gibberellic acid is supplied exogenously. The other light-induced responses mentioned earlier can be simply explained by the same general hypothesis, and also the effects of vernalization if it is assumed that low-temperature treatments are also concerned with building up a suitable concentration of gibberellin-like hormone.

This scheme owes much to those of Borthwick, Hendricks and Parker[27] and Liverman and Bonner[28], proposed before the significance of the gibberellins was appreciated. It accounts for most observed facts. It is based on hormones known to exist, but the proposed relationship between light and biosynthesis of gibberellin-like hormones is purely speculative. The scheme as proposed requires that the effects of exogenous gibberellic acid should be reversed by far-red light. The evidence on this point is conflicting[7,29].

No mention has been made so far of the ultimate flower-forming substance or flowering hormone, 'florigen', generally supposed to be identical in long-day and short-day plants. If such a substance is in fact produced, then, if the scheme proposed above is even approximately correct, florigen must be formed at a later stage in the series of reactions initiated by exposure to light than the gibberellin-like hormone. It must be assumed that florigen is elaborated in long-day and short-day plants in different circumstances, namely, in long-day plants only when levels of the gibberellin-like hormone are high, in short-day plants only at some lower critical level. I hope to elaborate these proposals and the supporting evidence more fully elsewhere.

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EFFECTS OF DISRUPTIVE SELECTION: THE EXPERIMENTAL PRODUCTION OF A POLYMORPHIC POPULATION

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In recent years greater attention has been given to classification of the different types of selection we must suppose to affect natural populations. Mather[1] discussed three types of selection: 'directional', the classic type which must occur if the mean value of a population's phenotype is not optimal in the mean environmental conditions of the population; 'stabilizing', which must occur when the extreme variants in the population are both unsuited to the environment; 'disruptive', which must occur when more than one phenotype is selected. An extreme form of disruptive selection is the direct antithesis of stabilizing selection and occurs when both extreme values are chosen as parents in each generation and the intermediate phenotypes are rejected. (Waddington[2] classified stabilizing selection into two types: 'normalizing' if the population responds by a reduction of the number of genotypes it produces; 'stabilizing' if it responds by an increase in the stability of the individual's developmental processes. Waddington's terminology is not used here as it classifies selection in terms of the mode of response of the population, and it is considered important to use a classification that depends only upon the observable phenotypes chosen as parents in each generation.) A fourth category might be added to Mather's classification, 'cyclic' selection, when a cycle of different optimum phenotypes in different generations is required[3], though its effects should probably be similar to those of disruptive selection as Mather[4] has pointed out.

A great deal of experimental work has been done on directional selection; but little has been done to determine the effectiveness of stabilizing or disruptive selection. Falconer and Robertson[5] compared the effects of stabilizing and disruptive selection for weight in mice, and observed a slight reduction of variation in their stabilizing line. Robertson[6] and Moree[7] showed theoretically that stabilizing selection should reduce and disruptive selection increase or maintain genetic variance; but Robertson expected the effect to be slight. Mather[4,8], on the other hand, has argued that disruptive selection should have profound effects, producing isolation if the different phenotypes selected can be independent, and polymorphism if they are in any way interdependent. He has also pointed out that only experiments on disruptive selection can elucidate the relative effectiveness of divergent selection and gene flow.

For some time we have maintained three lines of *D. melanogaster*, all derived from the same 'wild' foundation stock, for the purpose of studying the effects of disruptive selection using sternopleural chæta-number as a character. The first is similar to the mouse line studied by Falconer and Robertson. In each generation, extreme high and extreme low chæta-number flies are chosen and cross-mated. The line has therefore been maintained under disruptive selection with negative assortative mating (D^-). The second is maintained under a system that permits disruptive selection with positive assortative mating (D^+). The system (Table 1) involves selecting high- and low-flies from each culture of the line and cross-mating the cultures, so that there are equal numbers of $H \times H$ and $L \times L$ cultures in each generation. (The first generation of selection in this line is the same as divergent directional selection. Thereafter, however, low- as well as high-flies are selected from high-parents and vice versa so that the disruptive effect is introduced.) The third line (S) is a control. It was taken from the first generation D^+ cultures, and maintained exactly as the D^+ line except that the flies selected always have chæta-numbers as close as possible to the mean originally shown by the base stock from which the lines all derived. It is under stabilizing selection. There are four single-pair cultures in each generation of each of these three lines.

Table 1. Mating and Selection System for the D^+ Line

Parents of generation	Culture A ♀ × ♂	Culture B ♀ × ♂	Culture C ♀ × ♂	Culture D ♀ × ♂
0	*R* × *R*	*R* × *R*	*R* × *R*	*R* × *R*
1	*HA* × *HC*	*HB* × *HD*	*LC* × *LA*	*LD* × *LB*
2	*LA* × *LD*	*LB* × *LC*	*HC* × *HB*	*HD* × *HA*
3	As 1			
4	As 2			
	etc.			

The entries designate the parents used for producing the culture in the generation indicated in the first column. *R* means a random fly from the base stock used to initiate the line. *H* indicates the highest, and *L* the lowest chæta-number fly found in the appropriate culture. The letters after *H* and *L*, namely, *A*, *B*, *C*, *D*, indicate the culture from which the fly was selected. Thus, culture *A* in generation 1 was set up by mating the highest female found in culture *A* in generation 0 to the highest male found in culture *C*.

Details will be published elsewhere; but the general results may be summarized as follows. The D^- line has behaved very much as Falconer and Robertson's corresponding mouse line behaved. The mean chæta-number has risen, but there have been no striking changes of within-culture variance except those that might be interpreted in terms of the scalar connexion between variance and mean. The D^+ line, however, first rose then fell in mean, with a corresponding rise and fall of variance (as compared with line S), but then (from generation 11 to 21) its within-culture variance rose significantly without change of mean. The S line shows little evidence of any change. There is no striking evidence in any of the lines of changes of stability of development as measured by sternopleural asymmetry.

Despite the lack of evidence of change of variance in either D^- or S, experiments on these lines have shown that they have, in fact, become very different. The D^- line is very responsive to ordinary directional selection (as is the D^+ line), whereas the S line is much less so. Fig. 1 shows the results of several divergent-directional selection experiments on these two lines, and Fig. 2 shows the results of a heritability test on each of them. There is no doubt that the effects of these two types of selection are very different, and that disruptive selection maintains a greater variety of effective genotypes than does

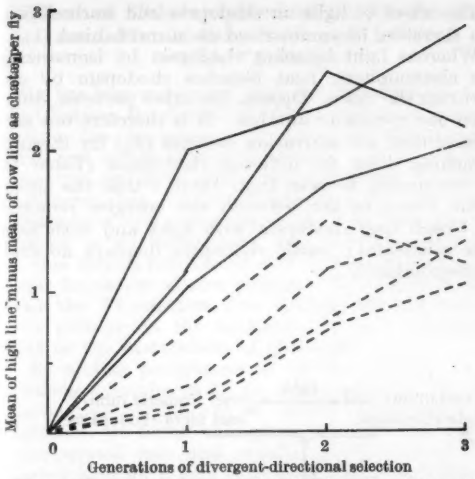

Fig. 1. The results of divergent-directional selection tests on the D^- (solid curves) and S lines (broken curves). Each test is performed by coincidentally extracting a high and a low selection line from the line to be tested, and plotting their divergence over three generations of selection. Each entry represents the difference between the mean of 160 flies from a high-line (20 flies of each sex from each of four single-pair cultures) and the mean of 160 flies from a corresponding low-line

stabilizing selection. In fact, there is more free variation in Mather's[9] sense in the D lines.

More striking results can be displayed for the D^+ line. Since there are in each generation of this line cultures with high and cultures with low chæta-number parents, we can observe the effects of selection by plotting the difference between the mean chæta-numbers of these two sub-populations in each generation (Fig. 3). In the first generation, of course, these differ considerably, since the first generation of selection is directional. Thereafter, the selection of low-offspring from high-parents and high-offspring from low takes effect, and the difference is reduced, sometimes to zero or even a negative quantity. In time however, the genetic constitution of the

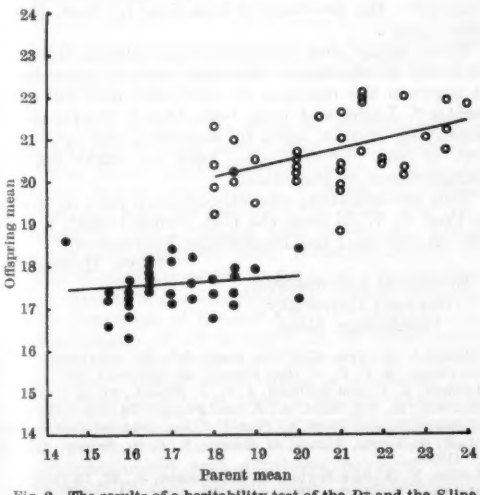

Fig. 2. The results of a heritability test of the D^- and the S line. The test was performed with positive assortative mating in single-pair cultures. Regressions of offspring mean on parent mean are plotted. Open circles, D^- line: regression significant ($P < 0{\cdot}01$). Solid circles, S line: regression not significant ($P \simeq 0{\cdot}5$)

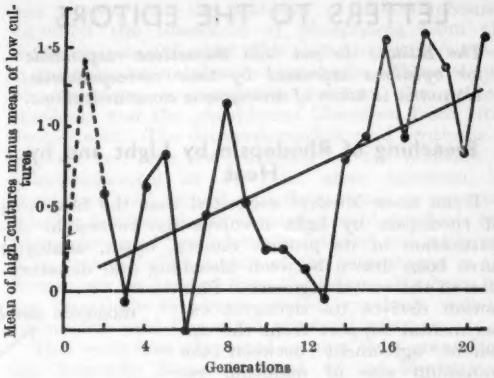

Fig. 3. The difference between the mean of the two high cultures and that of the two low cultures in the D^+ line. The regression of difference on generations calculated for generations 2–21 is plotted

population is so altered that a consistent positive difference of the same order of magnitude as that in generation 1 is established. The regression of difference on generations from generations 2–21 is positive and significant ($P < 0{\cdot}01$).

Now the two sub-populations of this line are selected (5 per cent selection) in opposite directions, but the gene-flow between them is maximal (50 per cent, that is, all matings are crosses between the two sub-populations). The experiment therefore shows two things, both of fundamental importance to population genetics. First, it shows that even 50 per cent gene-flow cannot prevent two sub-populations diverging under divergent selection pressures. It should be stressed in this connexion that we seldom consider that as much gene-flow as is implied in random mating (25 per cent) is likely often to occur in Nature, and the effects demonstrated by this D^+ line in a mere 21 generations are therefore likely to be slight compared with those that Nature might produce.

Second, it seems fair to suggest that the D^+ line must now be classed as a polymorphic population. The difference between the two components is not discontinuous, and it does not, therefore, fall strictly into the definition of a polymorphic population given by Ford (for example, ref. 10). Nevertheless, two distinguishable components are being maintained in the population and the difference between them is statistically highly significant, and this would seem to be the essential feature of polymorphism. The experiment, therefore, provides strong evidence supporting Mather's argument that disruptive selection could have polymorphism as its outcome.

Detailed explanation of the differences now distinguishing these lines will require further work. It is, however, secondary to the demonstration that disruptive selection can have these most important effects.

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LETTERS TO THE EDITORS

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Bleaching of Rhodopsin by Light and by Heat

Ever since Mirsky[1] suggested that the bleaching of rhodopsin by light involves the reversible denaturation of its protein moiety, opsin, analogies have been drawn between bleaching and denaturation of the visual pigments. This notion derives its strongest experimental support from the apparent agreement between the minimum size of quantum required to bleach frog or cattle rhodopsin with light[2] (48,500 cal./mole) and the Arrhenius activation energy (E_a) for the thermal bleaching of frog rhodopsin[3] (44,000 cal./mole). We find that this analogy breaks down on closer examination, and that light and heat bleach rhodopsin by different mechanisms, yielding different products.

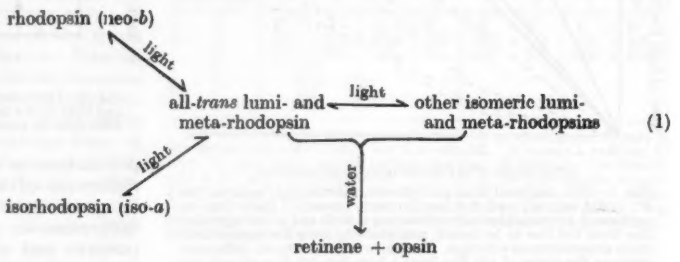
This is shown most convincingly by examining both rhodopsin and isorhodopsin. These two photosensitive pigments differ only in the geometrical configurations of their chromophores, rhodopsin being derived from neo-*b* (11-*cis*) retinene, and isorhodopsin from iso-*a* (9-*cis*) retinene[4]. Both bleach in the light to all-*trans* retinene and opsin[4]. The mechanism of photochemical bleaching is discussed more fully elsewhere[5]. Briefly, we find that light bleaches rhodopsin and isorhodopsin by isomerizing their chromophores to the all-*trans* configuration, yielding as first products the chromoproteins, all-*trans* lumi- and meta-rhodopsin. These in turn can be isomerized by light to a steady-state mixture of chromophores, all still attached to opsin: neo-*b* (= rhodopsin), iso-*a* (= isorhodopsin), and all-*trans*, neo-*a*, etc. (= the stereoisomeric lumi- and meta-rhodopsins). (It should be noted that we are defining lumi- and meta-rhodopsin as those stereoisomeric chromoproteins which are readily hydrolysed to retinene and opsin; or said another way, all possible stereoisomers of the chromophore except neo-*b* and iso-*a*. In our experiments so far, however, lumi- and meta-rhodopsin have always been predominantly in the all-*trans* configuration.) The meta-rhodopsins are relatively unstable and hydrolyse to retinene and opsin (bleaching); the neo-*b* and iso-*a* fractions of the steady state mixture constitute regenerated rhodopsin and isorhodopsin[6,7]. After exhaustive irradiation with white light, the final mixture usually consists of about 1 part rhodopsin and isorhodopsin, and 1 part retinene and opsin[6,7].

Table 1. Minimum Size of Quantum required to bleach Rhodopsin with Light, and the Arrhenius Activation Energy (E_a) for Thermal Bleaching

Rhodopsin	Minimum quantum energy (cal./mole)	Ref.	Arrhenius energy (cal./mole)	Ref.
Frog	48,500	2	44,000	3
Cattle	48,500	2	100,000	8
Squid	Not measured		71,800	9

The effect of light on rhodopsin and isorhodopsin can therefore be summarized as in mechanism (1).

Whereas light bleaches rhodopsin by isomerizing the chromophore, heat bleaches rhodopsin by denaturing the opsin. Opsins, like other proteins, differ from one species to another. It is therefore not surprising that the activation energies (E_a) for thermal bleaching differ for different rhodopsins (Table 1). It can readily be seen from Table 1 that the agreement found earlier between the energies required to bleach frog rhodopsin with light and with heat was accidental; cattle rhodopsin displays no such correspondence.



(1)

The products of thermal bleaching are denatured opsin and retinene, virtually unisomerized from its configuration in the chromophore. The thermal bleaching of rhodopsin or isorhodopsin yields about 70 per cent of the retinene in the original neo-*b* or iso-*a* configurations[8,9]. The process of thermal bleaching can therefore be summarized as:

$$\text{rhodopsin} \xrightarrow{\text{heat}} \text{neo-}b\text{ retinene} + \text{denatured opsin}$$

$$\text{isorhodopsin} \xrightarrow{\text{heat}} \text{iso-}a\text{ retinene} + \text{denatured opsin} \qquad (2)$$

The complementary nature of mechanisms (1) and (2) is emphasized by the fact that the products of bleaching by light regenerate rhodopsin or isorhodopsin upon addition of the appropriate isomer of retinene[4]; the products of bleaching by heat, if one adds opsin[8].

There is by now considerable evidence that the integrity of rhodopsin depends upon a close steric fit between the retinene chromophore and the opsin surface[10]. Light and heat both bleach rhodopsin by destroying this fit, light by attacking the configuration of the chromophore, heat by attacking the configuration of the opsin.

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Effect of Chloramphenicol on Ribonucleic Acid Metabolism in *E. coli* infected with T2 Phage

IT has been suggested[1] that the *T*2-phage infection first induces the formation of new protein in bacteria before the appearance of phage deoxyribonucleic acid and phage-antigenic protein. Quite recently, however, we have made the important additional discovery that the phage infection also induces a synthesis of new ribonucleic acid, or at least a specific change in its metabolism, and that the formation of this special ribonucleic acid is independent of the prior formation of new protein. These facts suggest that the *T*2-infection first induces the synthesis of new protein via the formation of new ribonucleic acid or the metabolism of this acid.

By adding phosphorus-32 to the medium or by diluting phosphorus-32 in the medium with non-radioactive phosphorus at various times after *T*2-infection, we found that phosphorus-32 was rapidly incorporated into and rapidly liberated from ribonucleic acid for a long time after infection, when the net ribonucleic acid synthesis had almost stopped. On the other hand, the ribonucleic acid-phosphorus in uninfected coli was reported to be metabolically inactive[2]. It was also found that the ribonucleic acid labelled with phosphorus-32 during the first 15 min. after *T*2-infection was different in mononucleotide composition from that of uninfected coli, confirming the results of Volkin *et al.*[3] (see Table 1). Thus the ribonucleic acid formed after *T*2-infection is distinct from that of uninfected host coli both in chemical composition and metabolic activity, and is therefore considered to be specific for *T*2-infection.

Table 1. PHOSPHORUS INCORPORATION INTO RIBONUCLEIC ACID MONONUCLEOTIDES OF *E. coli B* (*A*-20) AFTER *T*2-INFECTION*. (MOLAR RATIOS)

	Guanylic	Adenylic	Cytidylic	Uridylic
Uninfected control	1·2$_7$	1·00	1·0$_2$	0·90
After *T*2-infection	0·80	1·00	0·64	0·98
After *T*2-infection Chloramphenicol (50 γ/ml.) added before infection	0·89	1·00	0·66	0·89

* Phosphorus-32 was fed during the first 15 min. after *T*2-infection, and the ribonucleic acid fraction obtained was hydrolysed by alkali and analysed by paper electrophoresis. The details of this experiment will be published elsewhere.

We then studied the effect of chloramphenicol on the ribonucleic acid metabolism in *T*2-infected coli. It was found that chloramphenicol, when added shortly before *T*2-infection, blocked the formation of protein and deoxyribonucleic acid, but not the ribonucleic acid synthesis after infection. The ribonucleic acid synthesis after infection seemed to be rather stimulated by the addition of chloramphenicol. This ribonucleic acid, which is formed without the prior formation of protein after *T*2-infection, is also characteristic of *T*2-infection in its mononucleotide composition (see Table 1). These results, which show that the *T*2-infection induces a synthesis of new ribonucleic acid or at least a specific change in its metabolism without the prior synthesis of new protein, are in great contrast with the findings that new deoxyribonucleic acid synthesis requires the prior formation of new protein after *T*2-infection[4,5].

The stimulation of the ribonucleic acid synthesis in infected coli was more easily found when chloramphenicol was added at 10 min. after infection. It was shown that the addition of chloramphenicol inhibited the liberation of phosphorus from the ribonucleic acid formed after infection and resulted in the stimulation of its net synthesis. There should be, therefore, a correlation between the protein synthesis and the phosphorus liberation from ribonucleic acid. The deoxyribonucleic acid synthesis in infected coli was not inhibited by the addition of chloramphenicol at 10 min. after infection, as Tomizawa *et al.* found[4], and there seems no apparent relation between deoxyribonucleic acid synthesis and ribonucleic acid breakdown in infected coli, although it is probable that a part of the phosphorus in the former can be derived from the latter. We have not yet been able to obtain protein synthesis without ribonucleic acid formation after *T*2-infection.

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Changes in Adenine Nucleotides of Squid Muscle

IT was reported in an earlier communication[1] that after slow freezing of carp muscle there is a very rapid splitting of adenosine triphosphate accompanied by an instantaneous deamination, as a result of which inosine monophosphate accumulated predominantly. The mechanism of these phenomena is assumed to be that the action of adenosine triphosphatase or adenosine monophosphate deaminase is not affected by such low temperatures, while that of 5′-nucleotide phosphatase is reduced[2]. On the other hand, we have investigated the changes of nucleotides in squid muscle under the same conditions as those described previously and the specific phenomena have been observed to differ from those of carp muscle. This will be described in the present communication.

Fresh squid muscle was kept at − 5° C. for 50 hr.; during the first 3 hr. the muscle was frozen completely. 2 gm. of frozen muscle were ground, by hand in a mortar, in 20 ml. 4 per cent perchloric acid solution. The extract was filtered, and the filtrate was used for analysis.

Adenine and hypoxanthine nucleosides and nucleotides were separated by the hydrochloric acid gradient elution system on 'Amberlite' *IRA*-400. Inosine and hypoxanthine were separated by paper chromatography. The details of the system[3] and the methods of paper chromatography[4] have already been described.

In Fig. 1 the concentrations of the compounds present after various time-intervals are shown. It can be seen that during the first 10 hr. a rapid dephosphorylation of adenosine triphosphate occurred with a concomitant accumulation of the diphosphate and of the monophosphate; furthermore, the monophosphate accumulated gradually during 25 hr. from the start, while the diphosphate decreased. Adenosine monophosphate thus formed,

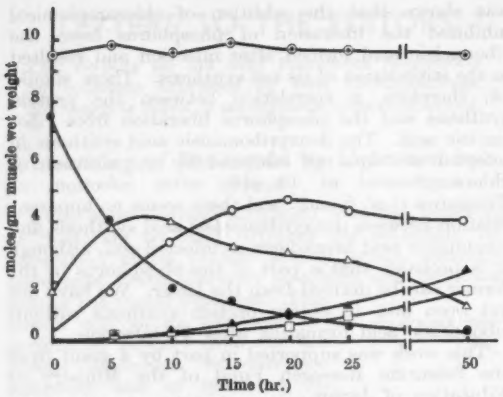

Fig. 1. Changes in the amounts of adenine and hypoxanthine compounds in squid muscle during storage at − 5° C. □, Hypoxanthine; ▲, inosine; ○, adenosine monophosphate; △, adenosine diphosphate; ●, adenosine triphosphate; ⊙, total purine compounds

without any conversion to inosine monophosphate, was converted to inosine and then to hypoxanthine. It was observed that these changes, which occurred in squid muscle, are almost quantitative. In squid muscle, as compared with carp muscle, two specific phenomena can be observed. The first is the accumulation of adenosine monophosphate. A possible pathway for the deamination of this substance, other than direct deamination, is by a combination of a 5′-nucleotide phosphatase with adenosine deaminase. This is supported by the fact that adenosine was converted to inosine very rapidly in crude extracts of squid muscle (Saito, T., and Arai, K., unpublished). The second is dependent upon the degree of splitting of adenosine triphosphate. In carp muscle there is a very rapid splitting as soon as freezing is complete, and at the same time inosine monophosphate accumulates; in squid muscle these specific phenomena are not observed.

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Amino-Acid Composition of Hæmoglobin from *Thunnus thynnus*

We have recently crystallized[1] hæmoglobin and myoglobin of the saltwater fish, *Palamys sarda* and *Thunnus thynnus*. Some physico-chemical and functional properties of these pigments have been described[2–4]. In this communication we report the amino-acid composition of *Thunnus thynnus* hæmoglobin, as determined by chromatography on an ion-exchange resin: a slightly modified version[5] of the method of Moore and Stein.

The hæmoglobin crystals, obtained from ammonium sulphate, were dissolved in water, dialysed against water and hydrolysed with 6 *N* hydrochloric acid for 24 hr. The quantity of protein present in each

Table 1. Amino-acid Composition of Crystalline *Thunnus thynnus* Hæmoglobin (gm. amino-acid/100 gm. Protein)

Amino-acid	Hydrolysate 1				Hydrolysate 2		Mean
Aspartic acid	11·77	11·00	9·97	11·69	11·4	11·28	11·18±0·31
Threonine	4·67	4·5	4·47	4·48	4·12	4·04	4·38±0·09
Serine	4·71	4·85	4·51	4·51	4·10	4·24	4·48±0·16
Glutamic acid	6·90	6·89	7·14	6·67	6·54	5·88	6·67±0·18
Proline	2·45	1·66	2·58	2·93			2·40±0·28
Glycine	4·45	4·49	5·08	4·38	3·87	3·82	4·34±0·22
Alanine	9·04	8·35	7·68	8·92	8·58	8·39	8·49±0·22
Valine	7·01		7·92	8·12	6·21	6·89	7·28±0·35
Methionine	3·22		2·37	2·37	2·51	3·59	2·81±0·26
*iso*Leucine	5·90		5·63	6·10	5·32	5·48	5·68±0·19
Leucine	12·74		11·80	11·73	11·11	11·28	11·73±0·30
Tyrosine	4·81	4·99	4·72	4·73	4·37	4·16	4·63±0·12
Phenylalanine	6·69	6·65	6·82	6·44	5·93	5·70	6·37±0·19
Histidine	4·04	3·98	4·20		4·42	4·02	4·13±0·10
Lysine	8·95	8·40	8·15		8·97	8·75	8·64±0·21
Arginine	5·67	5·73			5·46	5·49	5·58±0·18
					Total		98·74

sample used for chromatography was calculated on the basis of the nitrogen content (determined by the micro-Kjeldahl method in quadruplicate), assuming the value 16 for the percentage of nitrogen. The analyses were performed on two different hydrolysates of the same sample of crystals.

The results are given in Table 1. The values for proline were calculated using the formula previously reported[5], since we did not obtain a good separation of this amino-acid from glutamic acid. No results for cystine are available, since the method used is not appropriate for this amino-acid, but it has been identified as cysteic acid by paper chromatography[2].

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Absolute Configuration of Enantiomorphic Carbanions involved in the Aldolase and Triose Phosphate Isomerase Reactions

Dihydroxyacetone phosphate is one of many biological compounds which contain a carbon atom attached to two identical and two dissimilar groups, that is, a carbon attached to groups *a*, *a*, *b* and *d*. When one of the identical groups of such an 'Ogston atom'[1] or 'mesocarbon atom'[2] participates in a reaction it is of interest to establish the identity of that group[3–6]. Aldolase and triose phosphate isomerase have been shown to labilize only one of the hydrogens bound to the carbinol-carbon of dihydroxyacetone phosphate, and it has further been demonstrated that a different hydrogen is labilized by each of these enzymes[7,8]. It is the purpose of this communication to establish the identity of the specific hydrogen

which is labilized in the reactions catalysed by aldolase and triose phosphate isomerase.

In a random aldol condensation involving dihydroxyacetone and D-glyceraldehyde it would be expected that four ketohexoses would be formed. These would be D-fructose, D-tagatose, D-psicose and D-sorbose[9]. Mechanistically, these four hexoses can be viewed as arising from paired reactions involving, in the transition state, two enantiomorphic carbanions derived from dihydroxyacetone (Fig. 1).

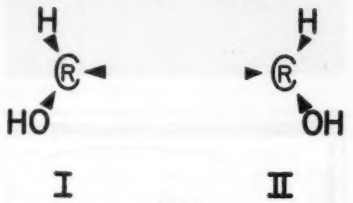
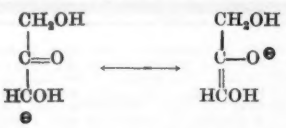


Fig. 1

It will be understood by this convention that the carbon in question is viewed so that three of the attached bonds lie in the plane of the paper. The carbon, the fourth bond, and its attached group (*R*) lie, in this order, behind the plane of the paper.

It should be pointed out that the anion resulting from the loss of a proton is a resonance system :



At the instant of condensation, however, the electron density is highest about the carbinol-carbon and may be viewed as having either structure I or II.

Carbanion I would give rise to D-fructose and D-tagatose on condensation with D-glyceraldehyde. Carbanion II, similarly, would give rise to D-psicose and D-sorbose. These conclusions can be easily verified with the aid of molecular models, and it is to be noted that, with the establishment of the absolute configurations of the tartaric acids[10], absolute configurations are represented by I and II. However, the alkali-catalysed aldol condensation of dihydroxyacetone and D-glyceraldehyde yields only D-fructose and D-sorbose. The failure of D-tagatose formation cannot be ascribed to its instability in alkali[11]. Thus the formation of only D-fructose and D-sorbose clearly demonstrates that whereas the reaction between dihydroxyacetone and hydroxyl ions leads to the formation of both carbanions non-stereospecifically, the condensation of each carbanion with the aldehydic moiety is stereospecific. Only those products are formed which have the *threo* configuration about the condensed carbons. Attention is directed to the fact that the condensation phase of the aldolase-catalysed reaction is also stereospecific, that is, only a *threo* product is formed. However, in contrast to alkali activation, the activation phase of the enzymatic reaction is stereospecific[7,8], which may account for the fact that the D-sorbose configuration is not produced.

On the basis of the above considerations, the previously established non-specificity of aldolase with respect to the aldehyde component, and the failure to detect an effect of aldolase on aldehydes[3,12], the possibility should be considered that the sole activating function of aldolase relates to dihydroxyacetone phosphate. The condensation phase of the aldolase reaction thus involves an aldolase–carbanion complex and aldehyde and would appear to be governed by the same mechanistic considerations as the condensation phase of the alkali-catalysed reaction.

In so far as the absolute configuration of the carbanion produced by the action of aldolase on dihydroxyacetone phosphate has been established, the geometry of the carbanion formed by the action of triose phosphate isomerase on this substrate can be readily deduced since it has been shown that these enzymes form enantiomorphic ions[7,8].

Carbanion I, formed by labilization of the hydrogen counter-clockwise to the hydroxyl, results from the action of aldolase, while carbanion II, produced by labilization of the hydrogen clockwise to the hydroxyl, is formed by triose phosphate isomerase.

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Action of the *Shigella shigae* Toxin after Intracerebral Injection

Using the technique of Feldberg and Sherwood[1], we injected small amounts of *Shigella shigae* toxin, prepared in a way previously described[2], into the left ventricle of unanæsthetized cats. Doses of 1–10 μgm. were used. For 3–4 hr. the behaviour of the animals did not change. Then gradually the cats became unusually quiet and sat still in their cage, although before they were very enterprising. Although a normal cat always tries to get out of the cage, these animals stayed in it in spite of the open door and when taken out and put on the floor of the room they invariably returned to the cage. They walked as if the co-ordination of the fore- and hind-legs was impaired. Their respiration was very rapid, the head showed a slight tremor, and they avoided light. This state continued for several hours. The animals kept their orientation, however. Even a 1-μgm. dose may kill a cat within 24 hr., a state of stupor with marked hypotonia preceding death.

Feldberg and Sherwood[3] and Gaddum and Vogt[4] observed behaviour changes quite analogous to those described here after intraventricular injections of 5-hydroxytryptamine in conscious cats. Serotonin release has been reported by Fink[5] when antigen was added to the sensitized mouse uterus. As serotonin is present especially near the third and fourth ventricle in the central nervous system[6,7], the

changes herein described might be a consequence of 5-hydroxytryptamine release, due to the toxin.

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Immunoelectrophoretic Evidence for the Presence of Two Precipitating Antibodies in Serum following Infection with the Virus of Foot-and-Mouth Disease

The results of the application of the technique of precipitation in agar gel to a study of the antigenic composition of the virus of foot-and-mouth disease have been reported by Brown and Crick[1,2]. It was tentatively concluded that two antibodies are present in the serum of guinea pigs and cattle convalescent from the disease on the evidence that (*a*) two precipitin lines were obtained when suspensions of the virus were diffused towards homotypic serum and (*b*) formation of one of the precipitin lines could be prevented if the immune serum was mixed with excess of the 7 mμ component of the virus before test. It was considered that the immunoelectrophoretic technique of Grabar and Williams[3], in which the protein mixture under examination is first separated in an electric field before analysis by diffusion, might provide further evidence on this point.

Hyperimmune guinea pig serum was first separated by electrophoresis in 1·5 per cent agar, under the conditions described by Grabar and Williams (0·05 *M* sodium veronal buffer, *p*H 8·2; 4 volts/cm.). Following electrophoresis, channels parallel to the direction of migration of the serum proteins were cut from the agar and filled with preparations of the virus or fractions separated from the virus. Two precipitin lines were formed between the separated serum and the channel containing the total virus preparation, showing quite clearly that separation of the two precipitating antibodies had occurred during electrophoresis (Fig. 1). If, instead of the total virus, a preparation of the 7 mμ component of the virus was placed in the channel, only one of the precipitin lines was then obtained. Similarly, a mixture of a virus preparation of the same immunological type and a heterotypic immune serum placed in the channel produced the other precipitin line. Brown and Crick[2] have shown that this mixture yielded a precipitin line identical with that produced by the 20 mμ component when it was diffused towards homotypic serum.

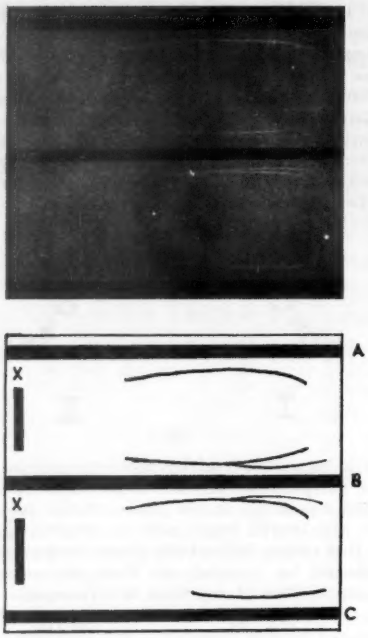

Fig. 1. Reaction of fractions of the virus of foot-and-mouth disease with homotypic immune guinea pig serum separated by electrophoresis in agar. The section of the plate on the negative side of the starting point (*X*) is shown. Channel *A* contains the 7 mμ component of the virus, channel *B* total virus suspension and channel *C* a mixture of total virus with a heterotypic antiserum

Additional evidence that separation of the two antibodies occurs during electrophoresis was obtained by testing sections of the agar along which the serum proteins had moved. These sections were placed in cups cut in an agar gel, and their contents allowed to diffuse towards a virus suspension. The precipitin line pattern obtained is shown diagrammatically in Fig. 2, from which it can be seen that, although most

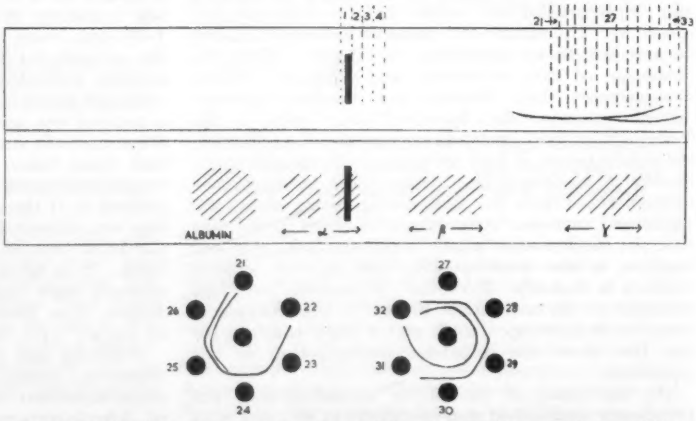

Fig. 2. Electrophoresis of guinea pig antiserum followed by diffusion against virus of the same type. Diffusion was carried out as described by Grabar and Williams and by removing sections of the agar and testing them in the hexagonal arrangement shown. The numbers of the cups correspond to the sections removed from the agar. The positions of the proteins separated during electrophoresis are shown in the lower lane (stained by amidoschwarz)

of the sections in the γ-globulin region gave two precipitin lines, only one line was obtained at each end of the precipitin range, corresponding to the line produced by the 7 mμ component (for the sections nearer to the starting point) and the 20 mμ component (for the sections nearer to the cathode). It will be noticed that the distance between the precipitin lines was not constant, indicating that the relative concentration of the two antibodies was different in each section. The corresponding precipitin line pattern obtained by the method of Grabar and Williams is shown alongside.

Evidence is also being accumulated which shows that stepwise precipitation of immune serum with increasing concentrations of ammonium sulphate yields fractions which contain the two precipitating antibodies in proportions different from that in which they are present in the original serum. There can be little doubt, therefore, that the two precipitin lines obtained when suspensions of the virus of foot-and-mouth disease are diffused towards homotypic immune serum are due to the presence of distinct antibodies in the serum.

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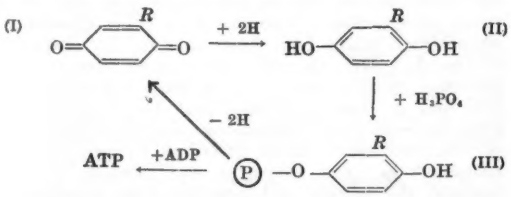
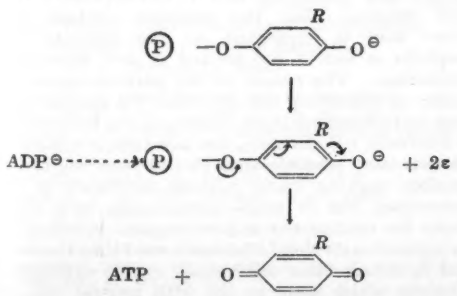
A Theory of Oxidative Phosphorylation

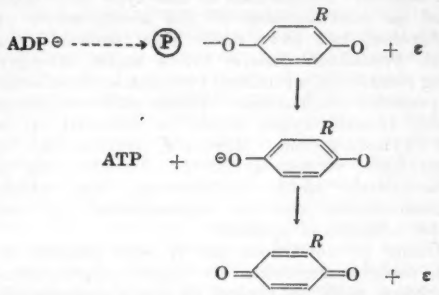
Evidence has been put forward that naphthoquinone derivatives take part in the phosphorylation of adenosine diphosphate to adenosine triphosphate by animal tissues[1], chloroplasts[2] and bacteria[3]. A similar role in phosphorylation by animal tissues has been proposed for α-tocopherylquinone[4]. It is therefore possible to formulate an earlier suggestion[5] in more general terms, as follows :



A substituted quinone (I) is reduced to the hydroquinone (II) and phosphorylated (III). Regarded as an attack by adenosine diphosphate$^{\ominus}$ the reaction (III)→(I) can be written :



If this scheme is correct, a function of ferric ions in (for example) cytochrome *c* may be to trap electrons liberated by the hydroquinone derivative during its oxidation. A two-stage process, involving a semiquinone anion, is perhaps more likely than not :



There is a formal similarity between the removal of electrons from compounds of type (III) by oxidizing agents and the activation of phosphoramidic esters by protonation ; these esters have been shown[6] to phosphorylate adenosine diphosphate to the triphosphate.

Although vitamin K_1 could affect metabolism in more than one way, chemical considerations would seem to point to coupled phosphorylation as the first choice.

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Constitution of Verdohæm

Verdohæm is an interesting intermediate through which the conversion of hæmin into biliverdin was first achieved[1]. In a recent paper[2], Rackow discusses its structure. He refers only to my first paper[1], but not to later papers[3–5] in which a modified formula with a ring containing an oxygen atom instead of one carbon atom of the porphyrin ring was suggested on the basis of new evidence. The structure suggested by Rackow is that of a pyridinium salt of an α-hydroxyporphyrin–iron complex carrying on its iron atom one molecule of pyridine and one molecule of oxygen bound as in oxyhæmoglobin.

The structure proposed by Rackow cannot be accepted for the following reasons :

(1) It does not account for the liberation of carbon monoxide, which has been demonstrated by Drabkin *et al.*[6] to occur during verdohæmochrome formation, not during its conversion into biliverdin. The previous inability to demonstrate this carbon atom was one of the main arguments of the Fischer school in favour of an intact porphyrin ring in verdohæm. Such compounds, of α-hydroxyporphyrin–hæm character, are indeed formed during the reaction as precursors of verdohæmochrome, and their spectroscopic similarity to verdohæmochrome explains Drabkin's

observation that the liberation of carbon monoxide occurs in the later stages of verdohæmochrome formation.

(2) Verdohæmochrome is far more stable than would be expected from the formulation as a hæmochrome–oxygen adduct. Compounds of this type have been assumed as intermediates in the autoxidation of hæmochromes, but have never been isolated. In contrast, verdohæmochrome exists under strongly reducing conditions, in neutral pyridine solution even in the presence of dithionite. Under such conditions reversibly bound oxygen would be removed, as is that of oxyhæmoglobin. Moreover, pyridine can be removed from verdohæmochrome, transforming it into moderately stable verdohæmin, from which verdohæmochrome can be reconstituted by the anaerobic addition of pyridine.

(3) Under no conditions has it been possible to reduce verdohæmochrome to α-hydroxyporphyrin hæmochrome with its typical phyllotype–porphyrin hæmochrome spectrum. This ought to be possible if the structure assumed by Rackow was correct.

(4) While the evidence of Rackow for the persistence of a ring-conjugated system of double bonds is not convincing, it may be pointed out that an oxygen-closed system does not preclude ring-conjugation (cf. the formula on p. 398, ref. 4).

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Temporary Nutritional Stress and Infertility in Mice

Exposure to high environmental temperature has reduced the fertility in females of a number of species of animals[1–5]. Injections of cortisone or adrenocorticotrophic hormone into pregnant rats, rabbits and mice caused embryonic deaths[5,6]. 36–48 hr. starvation at the time of exposure increased the susceptibility of mice to *Staphylococcus aureus* infection[7]. Temporary reduction in pasture 'quality' at the time of mating has been associated with bovine female infertility (McClure, unpublished data).

These facts suggested that a temporary nutritional stress at or about the time of mating may be able to cause infertility. To test this hypothesis, mice were subjected to transitory nutritional stress at or about the time of mating.

Two groups of mice were used: (*a*) a control group of 19 female mice, which were given free access to food; (*b*) a treated group of 18 female mice, which were given free access to food except for three 48-hr. periods of complete starvation separated by two 48-hr. periods of normal feeding. The first starvation period commenced on the day male mice were introduced. Water was freely available to both groups at all times.

In the control group 9 out of 19 mice littered (59 young, average 6·6) from matings which were presumed to have occurred in the first ten days of the experiment. None littered from matings which may have occurred from the eleventh to the sixteenth day.

In the treated group none of 18 mice littered to possible matings in the first ten days of the experiment, that is, the period during which the mice were subjected to the nutritional stress. Seven mice littered (49 young, average 7) from matings which were presumed to have occurred within the six days after the period of starvation.

These results suggest that short periods of starvation at or about the time of mating may be detrimental to the fertility of mice, and that the residual effect of the starvation is short.

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Affinity of Neutral Red for Cells with Basophilic Cytoplasm

In earlier studies[1,2] it was found that within half an hour of mice being injected with the dye neutral red, the cytoplasm of the exocrine cells of the pancreas became diffusely and homogeneously pink. A short time later, small reddish granules, the so-called 'neutral red granules', appeared. Shortly after injection these granules were discrete, but later took the form of aggregates immiscible with the cytoplasm. The single granules were about 0·7μ in diameter, the aggregates 2·5–3μ, and both were confined to the basophilic portion of the cell between the zymogen granules and the basement membrane. They did not occur among the zymogen granules and were never intranuclear. Vacuoles with these characteristics which might have been coloured by entrance of the dye into the cell were never observed in pancreas exocrine cells from animals not given the dye and it was concluded that the neutral red granules were 'new' formations. By the application of two techniques, Janus green[3] in living cells and Altmann[4] in fixed tissue, it was possible to distinguish the neutral red granules from apparently normal mitochondria.

In subsequent studies utilizing appropriate fixation and staining methods, we have confirmed Chlopin's[3] observation that the neutral red granules are basophilic and pyroninophilic. This latter evidence that the granules contain ribonucleic acid is supported by our findings that basophilia is lost if the section is first exposed to ribonuclease. The nature of the particle apparently capable of extracting the dye from the general cytoplasm and concentrating it, leading to the formation of the intensely red granules, has not been established. It seems very possible that in the pancreas the responsible element under normal conditions is submicroscopic, but is made microscopic only by its affinity for neutral red and subsequent swelling. In this connexion, it should be mentioned that there also occur in certain other cells[5] easily visible cytoplasmic inclusions which stain in life with neutral red, but

do not require the application of this dye to make them visible. Their relationship to the granules which appear as 'new' formations is not clear.

Weiss[7], in a recent electron microscope study, concluded that the neutral red granules in the pancreas were probably mitochondria that had taken up the dye. This conclusion is difficult to accept in view of their morphology, basophilia, apparently high content of ribonucleic acid, differentiation from mitochondria by classical cytological methods, and the fact that they reduce silver and osmium or are sudanophilic when methods for demonstrating the Golgi substance or lipochondria are applied. Further evidence against the neutral red granules being mitochondrial in origin is the observation that the ability of a cell to form neutral red granules is more a function of its basophilia and not the number of mitochondria it contains. Thus the pancreas exocrine cell, which contains relatively few mitochondria, shows marked neutral red granule formation, in contrast to the liver cell, which possesses many mitochondria yet exhibits only a moderate number of neutral red granules. Further, when one examines grossly an animal given neutral red one is immediately impressed by the intense red staining of the pancreas and salivary gland over all other tissues. When they are examined microscopically they contain the largest number of neutral red granules, the bowel and liver a moderate number, and the kidney, lung and brain relatively few.

The affinity of this cytoplasmic component for neutral red would seem to be more complex than a simple reaction of nucleic acids with a basic dye[8], since a number of other dyes, such as methylene blue, pyronin *Y*, azure *B* and coriphosphene of rather similar molecular weight, basicity and solubility, do not lead to similar granule formation. Acridine orange is the only one found thus far which will produce very similar results. In this regard it might be mentioned that Karreman *et al.*[9] have recently reported that acridine orange inhibits contraction of muscle, apparently because it acts in competition with adenosine triphosphate to form complexes with the same muscle constituents.

The *in vivo* affinity of neutral red for particular areas of cytoplasm rich in ribonucleic acid might conceivably alter the normal mechanisms for protein synthesis by the formation of dye–ribonucleic acid complexes. In view of this possibility it may be that this substance will find application in the investigations in this field.

I am grateful to Dr. Benjamin Castleman, Dr. E. B. Keller and Dr. Jesse F. Scott for their discussions and criticisms of this work. These studies were supported in part by grants from the American Cancer Society (*C*-22) and the United States Public Health Service (*RG*-4646).

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Increase of 5-Hydroxytryptamine in Blood Platelets by Isopropyl-isonicotinic Acid Hydrazide

IT has been found that isopropyl-isonicotinic acid hydrazide (iproniazid, 'Marsilid') causes an increase of the 5-hydroxytryptamine (serotonin) and norepinephrine content of the brain in various animal species[1,2]. Furthermore, a significant rise of the catecholamine content in the myocardium of guinea-pigs could be observed after administration of iproniazid[3]. These effects are probably due to inhibition of monoamine oxidase, an enzyme which is present in brain and in heart and which is markedly inhibited by iproniazid. Isonicotinic acid hydrazide (isoniazid, 'Rimifon'), a compound which inhibits monoamine oxidase much less than iproniazid, causes little or no rise of the above-mentioned amines in brain and heart[3–9].

In blood, the platelets contain 5-hydroxytryptamine, the physiological role of which is not known definitely. It seemed therefore of interest to investigate whether iproniazid had an influence on the 5-hydroxytryptamine content of blood platelets as well as on the blood morphology, bleeding and coagulation time. The amount was measured by a spectrophotofluorimetric method[10].

In whole blood of four rabbits, daily administration of 30 mgm./kgm. of iproniazid for 4 days caused a marked increase of 5-hydroxytryptamine in every case. This was still detectable 3 days after the administration of the drug had been stopped. In each of five humans, the platelet 5-hydroxytryptamine rose gradually after daily oral administration of 5–8 mgm./kgm. iproniazid (Fig. 1). In five additional humans the average increase was 78 per cent (30–139 per cent) after daily oral administration of 3 mgm./kgm. of iproniazid for 7–9 days. Isoniazid caused a much less marked elevation as compared with iproniazid. Thus, it seems probable that the rise in 5-hydroxytryptamine in platelets after iproniazid administration is connected with monoamine oxidase inhibition.

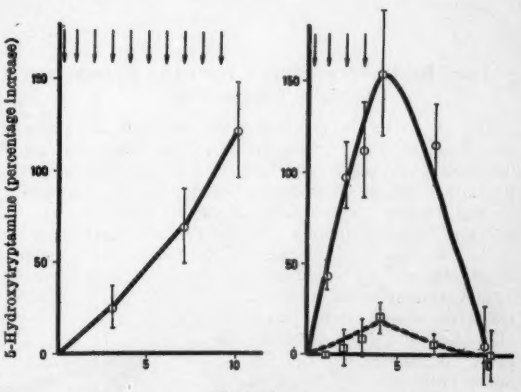

Fig. 1. Influence of iproniazid and isoniazid on the 5-hydroxytryptamine content of blood and platelets. The points represent the average percentage 5-hydroxytryptamine increase of each group. Each individual served as its own control. Left-hand curve: isolated platelets in five humans. The 5-hydroxytryptamine content was referred to the platelet number. Arrows, oral administration of 5–8 mgm./kgm. of iproniazid. Right-hand curves: whole blood of rabbits. Solid line, administration of 30 mgm./kgm. of iproniazid (arrows) in four rabbits. Dotted line, administration of 23 mgm./kgm. of isoniazid (equimolecular dose to iproniazid; arrows) in four rabbits. Vertical lines, standard deviation

No change in bleeding and clotting time could be found in humans 10 days after daily administration of the stated iproniazid doses. In all the five humans receiving an iproniazid dose of 5–8 mgm./kgm., a rise in the number of platelets was seen. The absolute and relative number, as well as the morphology of the other blood cells, was not altered by the drug.

There is a possible connexion between the increase in the number and the 5-hydroxytryptamine content of platelets. It has been shown that 5-hydroxytryptamine administered by itself causes a rise of the platelet number also[11,12]. The mechanism which leads to this increase is not yet known.

It is conceivable that certain pharmacological actions of iproniazid are mediated by the increased 5-hydroxytryptamine in platelets. This might be the case, for example, for certain effects of iproniazid on the heart, since the cardiovascular system is relatively sensitive to 5-hydroxytryptamine[13].

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Two Inhibitory Fibres forming Synapses with a Single Cell

Drs. A. S. V. Burgen and S. W. Kuffler claim[1] that the dual inhibitory regulation of one cell by two neurons with distinctly different physiological performance which they found in the stretch receptor of the lobster (presumably *Homarus vulgaris* ?) is a phenomenon which has not been found elsewhere.

It has also been found in the limbs of decapod crustaceans. The opener and stretcher muscles are innervated by branches of the same single motor axon and also by the same 'common' inhibitor axon. In order that the two muscles may function independently they also receive in some species 'specific' or 'true' inhibitor axons. Thus the muscle fibres receive a double inhibitory nerve supply. Wiersma[2] showed that there are distinct physiological differences between the two (see also refs. 3 and 4). The ratios of frequency of inhibitory to that of excitatory stimulation for just complete inhibition are different in the two cases. Also, the specific inhibitor in crabs can give supplemented (α-inhibition) whereas the common one cannot. Hoyle and Wiersma[5] have studied these phenomena with the aid of intracellular recording electrodes.

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Erythropoiesis in Nephrectomized Dogs

The striking disappearance of erythroblasts from the bone marrow of bilaterally nephrectomized dogs, kept alive by peritoneal dialysis, has been reported[1]. Erythroblastopænia is likewise observed in patients with acute renal failure, but does not occur in cases of chronic uræmia, in spite of similar non-protein nitrogen blood-levels in the two situations. These observations suggest that the kidney produces a specific erythropoietic factor. The present study with iron-59 demonstrates the abolition of erythropoiesis following bilateral nephrectomy.

Seven bilaterally nephrectomized and seven intact dogs were studied, Unilateral nephrectomy was performed initially, the remaining kidney being removed 15–30 days later.

Dogs were kept alive by two or three daily peritoneal washings, according to Grollman's procedure[2]; 72 hr. following the second nephrectomy, 5 μc. of iron-59, previously incubated in 20 ml. of plasma, were given intravenously. Blood samples were collected every 45 min. during the first three hours and afterwards every two days.

The curves of disappearance of iron-59 from the plasma of the normal dogs and of the nephrectomized ones are shown in Fig. 1. The average time at which half the activity initially present had disappeared ($T1/2$) in the nephrectomized dogs was 279 min., as compared with 89 min. in normal dogs.

The plasma iron turnover-rate was also decreased in the nephrectomized group: 0·09–0·49 mgm./kgm./day (mean, 0·27) against 0·25–0·92 (mean, 0·64) in the control group.

In the control group, incorporation of iron-59 into erythrocytes was between 60 and 80 per cent of the injected dose and was maximal between the third and the eighth day. Incorporation was definitely

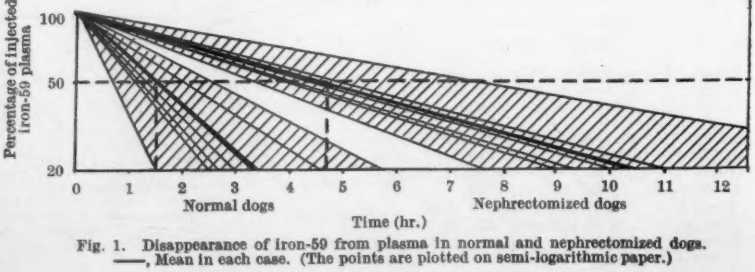
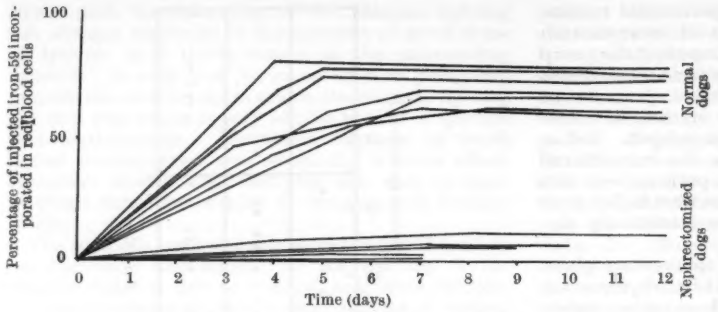


Fig. 1. Disappearance of iron-59 from plasma in normal and nephrectomized dogs. ——, Mean in each case. (The points are plotted on semi-logarithmic paper.)



[Fig. 2. Uptake of iron-59 into erythrocytes

decreased in the nephrectomized group, being less than 3 per cent in four animals, and not higher than 12 per cent in the others (Fig. 2).

The difference between the mean values obtained on the normal dogs and those obtained on the nephrectomized dogs is significant.

According to these observations, it can be concluded that bilateral nephrectomy abolishes erythropoiesis. The question arises whether suppression of that function is due to retention of toxic products, or related to the absence of a hypothetical renal stimulating factor.

The facts supporting the latter hypothesis are: (1) the difference in the bone-marrow smears of patients with acute anuria as compared to those with chronic uræmia[3]; (2) the only slightly decreased incorporation of iron-59 in chronic uræmic patients[4]; (3) the observations of Jacobson[5] demonstrating the absence of cobalt-induced erythropoietic stimulation in nephrectomized rats.

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24-Hr. Rhythms in Blood Eosinophils and *Wucheria bancrofti* Microfilariæ Before and After Δ^1-9α-Fluorocortisol

WE wished to investigate whether the adrenal cortex, which controls 24-hr. periodic phenomena at several levels of mammalian organization, in blood, cytoplasm and nucleus (for review, see ref. 1), also contributes to periodic host–parasite relationships[2].

On 12 patients with *Wucheria bancrofti* infestation, microfilarial[3] and eosinophil[4] counts were made with capillary blood, obtained at 90-min. intervals for periods of up to 24 hr. Microfilarial as well as eosinophil counts were lower in the morning than during the rest of the day, but the correlation between the two rhythms was not statistically significant. The microfilarial rhythm was more regular and had the greater amplitude, involving increases of more than 100 per cent and decreases to less than 10 per cent of the day-mean. The eosinophil count, in turn, was higher at 2300 than at 1230 or 1400 hr. ($P = 0{\cdot}006$), in each case, but the overall diurnal changes in these tropical subjects with various parasites were more irregular than those recorded for non-infested subjects studied in the temperate zone[4], perhaps as a result of the multiple parasitic infestations and the tropical 'routine' or, perhaps, lack of routine.

We then turned to a study of an adrenal inhibitor, Δ^1-9α-fluorocortisol, given to three patients for a 3-day period; profiles of microfilarial and eosinophil counts were made before and after its administration. Study of Fig. 1 reveals in each profile an eosinophil rhythm as well as a highly significant microfilarial rhythm. The eosinophil counts of the second profile further suggest an 'escape' from Δ^1-9α-fluorocortisol; the counts at 0930 hr., at the start of the second profile, are lower than those obtained 24 hr. later. 17-Ketosteroid values determined for urine samples collected during the 24-hr. period of each profile are shown at the bottom of Fig. 1. In each case, the 24-hr. excretion of 17-ketosteroids was lower after treatment than before, but this depression was slight. 17-Ketosteroid and eosinophil behaviour suggest that, at the time of the second profile, the patients were escaping from adrenal cortical inhibition by Δ^1-9α-fluorocortisol. Therefore, the persistence of microfilarial rhythm after a 3-day course of Δ^1-9α-fluorocortisol may not be interpreted as occurring during adrenal insufficiency. But, in comparing microfilarial behaviour before and after treatment, it appears that the ascending and descending phases of the microfilarial rhythms in the three subjects were more closely 'synchronized' in the second profile, as compared to the first (Fig. 1). One possible effect of

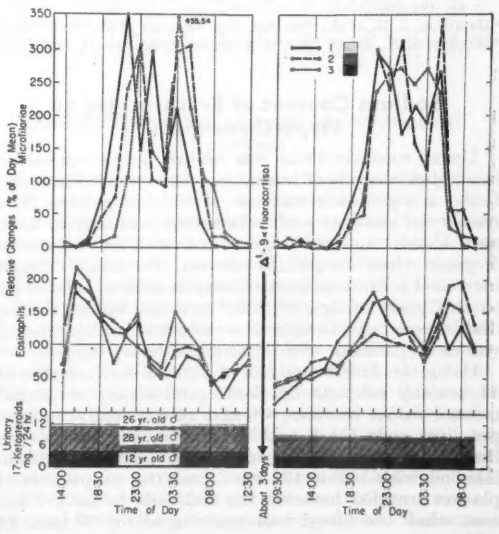

Fig. 1

Δ^1-9α-fluorocortisol and/or the experimental routine thus concerns the phase relations of (microfilarial) rhythm in the three individuals composing the group studied (the studies on the three subjects were carried out at the same time). Another effect of treatment relates to the time relations of the rhythms in microfilariæ and eosinophils, in a given subject. Before treatment, correlation coefficients for microfilarial and eosinophil counts in the three patients were not significant, whereas all three r values were higher after treatment and two of these were statistically significant.

Those factors which determine the various phase relations of certain mammalian 24-hr. rhythms are not necessarily analogous with those physiological mechanisms which maintain a given rhythm[1]. The question whether or not the adrenal cortex is critical for the maintenance of microfilarial periodicity awaits further study, in subjects with verified cortical adrenal insufficiency. Microfilarial periodicity may persist in such cases, as does the 24-hr. rhythm in serum iron from patients suffering from Addison's disease[5,6]. The data shown herein suggest, however, that certain phase relations of microfilarial periodicity may be influenced by exogenous corticoids and may, perhaps, be regulated by endogenous periodic cortical adrenal secretions.

This work was aided by grants from the Universities of Ceylon and Minnesota (Graduate School) and the Elsa U. Pardee Foundation. We are indebted to Dr. F. Bartter of the National Institutes of Health, Bethesda, Md., for suggestions regarding the Δ^1-9α-fluorocortisol administration and for helpful comments on this communication.

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Sodium Content of Erythrocytes in Hyperthyroidism

Until recently little was known about variations in sodium content of human erythrocytes. Harrison[1] found a significant increase of red-cell sodium in a number of patients with tuberculous meningitis, Love and Burch[2] noticed higher cell sodium values in Negroes than in White donors, Overman[3] found increased sodium concentrations in normal infants up to two years of age, Nichols[4] saw low values during diabetic acidosis, Roegholt[5] sometimes found increased values in patients with congestive heart failure.

Using the direct analysis of diluted erythrocytes of 41 healthy subjects by flame photometry we found normal values between 8·6 and 12·9 m.equiv. sodium per litre cells (11·8 and 17·7 m.equiv. sodium per litre cell water). By means of human albumin labelled with iodine-131 we found the proportion of plasma trapped between the red cells to be 1·7 per cent when the blood was centrifuged for 60 min. at 2,700g.

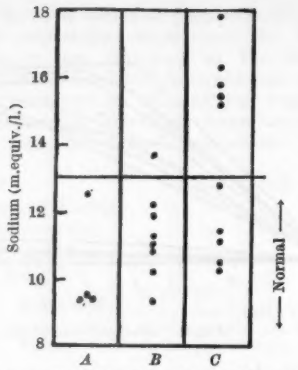

Fig. 1. Sodium content of erythrocytes of subjects with low (*A*), normal (*B*), and high (*C*) thyroid function

In agreement with Keitel *et al.*[6] we found a variation in the composition of erythrocytes from different portions of the centrifuged cells, the middle layer showing a sodium content 1 m.equiv. lower than the top and bottom layers.

We examined the cell sodium of 22 patients whose thyroid function was determined by giving tracer doses of iodine-131 (Fig. 1). In the subjects with low or normal thyroid function the cell sodium with one exception was normal. In 50 per cent of the subjects with high thyroid function a significant increase of cell sodium with a normal amount of cell water was observed. Two cases with high cell sodium were followed up after thyroidectomy; during the next 5 months the cell sodium decreased gradually to normal values.

These results suggest a relationship between the red cell sodium and hyperthyroidism.

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Comparison of Effect of Lysergic Acid Diethylamide with Potassium Cyanide and other Respiratory Inhibitors on the Siamese Fighting Fish

Although it is known that lysergic acid diethylamide enters the brain, the mechanism by which it acts to produce the psychotic patterns in man is unknown. Experiments which are designed to investigate the brain process in the intact animal might lead to a concept that could be developed to study the chemical process originating or connected with clinically occurring schizophrenia.

We have recently been studying the effect of potassium cyanide, sodium azide, hydrazine and lack of oxygen among other respiration inhibitors on an intact animal, the Siamese fighting fish. In addition, the action of oxidation-reduction indicators like methylene blue, Bindschedler's green and other dye systems have been explored. It has previously been

shown that the behaviour of the Siamese fighting fish changes markedly in the presence of small doses of lysergic acid diethylamide in the surrounding water[1,2]. It may now be reported that potassium cyanide and sodium azide act on the Siamese fighting fish in a way which is very similar to that of lysergic acid diethylamide. Hydrazine sulphate in much higher concentration was essentially without effect. However, anoxia and asphyxia can also produce reactions somewhat similar to lysergic acid diethylamide.

The methods used were those previously described by Abramson and Evans[1] for the reaction of the Siamese fighting fish to lysergic acid diethylamide. For the purpose of this study, four of these, or related criteria, were usually chosen for analysis, as described by Abramson, Sklarofsky, Baron and Gettner[2].

With concentrations of potassium cyanide analogous to those used to obtain readily observable effects of lysergic acid diethylamide, that is, 1 μgm. per ml. in the outside liquid, the fish, in general, act as if they were under a slightly lower concentration of lysergic acid diethylamide, rising to the surface and assuming a nose up–tail down position. The Cartesian diver position is often assumed, although some of the motor characteristics of the effect of lysergic acid diethylamide are different. Casual inspection of fish under lysergic acid diethylamide and potassium cyanide might not reveal an important difference in the response. However, certain differences in the response are present, and a trained observer can usually distinguish between the effect of cyanide and the effect of lysergic acid diethylamide, especially by the absence of the kinking of the tail. Apparently, the potassium cyanide is utilized more rapidly than lysergic acid diethylamide by the fish, because if the fish are transferred to fresh water, they recover faster from the former than they do from the latter.

Hydrogen sulphide at high concentrations (100 μgm. per ml.) was lethal, but the surviving fish assumed a nose up–tail down position at the surface. The effect of hydroxylamine hydrochloride up to concentrations of 100 μgm. per ml., as well as hydrazine sulphate to 10 μgm. per ml. has thus far been negative. Most interesting was the effect of azide. Although sodium azide is more toxic than potassium cyanide, an effect analogous to lysergic acid diethylamide is readily observed at concentrations of sodium azide similar to those observed for lysergic acid diethylamide.

Preliminary results indicate that a decreased oxygen supply with simultaneous prevention of accumulation of carbon dioxide resulted in the nose up–tail down position similar to lysergic acid diethylamide in several hours—the fish remaining alive. When carbon dioxide was permitted to accumulate in the absence of renewed oxygen all the fish assumed the nose up–tail down position in several hours. They rose rapidly to the surface when disturbed. Recovery was rapid from both anoxia and asphyxia. Experiments are in progress with improved techniques of observation.

A concentration of methylene blue of 100 μgm. per ml. produced a suggestive lysergic acid diethylamide reaction. Bindschedler's green affected the fish, producing a noticeable excitatory period; 20 μgm. per ml. produced the nose up–tail down position with no kink in the tail. In a comparative experiment 20 μgm. per ml. of Bindschedler's green was more effective than 1 μgm. of potassium cyanide. It is of interest that the effect of methylene blue increased with time. 50 μgm. per ml. of toluene blue and indigo disulphonate were without an important effect. 50 μgm. per ml. of indigo tetrasulphonate was also ineffective. Sodium 2,6-dichlorobenzene indophenol was effective, the effect increasing with the concentration up to 50 μgm. per ml., where an effect equivalent to 1 μgm. per ml. of lysergic acid diethylamide was observed. Although 50 μgm. per ml. of gentian violet and methyl violet killed the fish, lower concentrations, 20 μgm. per ml. of each, produced a nose up–tail down position in more than half the fish at the end of 4 hr.

It has often been observed that human subjects under the influence of comparatively small doses of lysergic acid diethylamide have the confusion and other symptoms that are associated with anoxia. Its effects in man, therefore, are not incompatible with the assumption that lysergic acid diethylamide in the fish and in man acts by poisoning some parts of the enzymatic processes connected with oxidation. Although at the time that this report was written we have not had access to the data dealing with the effects of non-lethal doses of potassium cyanide on the mental state of man, the available data in the literature indicate that an exogenous psychosis with loss of sense of reality is produced with non-lethal doses. Indeed, potassium cyanide has been used in the therapy of schizophrenia, apparently to stimulate the respiratory enzymes. It is worthwhile on the basis of these results to explore the possibility that not only the lysergic acid diethylamide psychosis in man may be connected with poisoning of special oxidative enzymes, but also that the schizophrenic process may be connected with a similar process where special respiratory enzymes of the brain are not functioning adequately.

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Lead-Reactive Substances in Myoneural Synapses

Biochemical investigations[1] have revealed that —SH compounds take an essential role in the transmission of impulses. By precipitating these compounds with lead nitrate we have succeeded in demonstrating the subneural apparatus of motor end-plates in cross-striated muscles.

Entire diaphragms of rats were fixed for 15 min. in 8 per cent formalin containing 5 per cent lead nitrate. Frozen sections of 30–40μ were cut, washed rapidly in distilled water and immersed in a 2 per cent aqueous solution of sodium sulphide. After this treatment the characteristic patterns of the subneural apparatus were visible.

Investigations as to whether other histological structures also contain a lead-reactive substance, and to determine what kind of chemical substances are responsible for this reaction are in progress. Localization of the lead-reaction in myoneural synapsis is

similar to that of cholinesterase activity[2–4]. According to Nachmansohn and Lederer[5], cholinesterase also contains free sulphydryl groups. The reaction described above does not take place, however, if the muscle is frozen or incubated in distilled water before treatment with lead nitrate, though neither treatment affects cholinesterase activity. It seems very likely, therefore, that reaction with lead is not due to cholinesterase, but to a substance of a smaller molecular weight, having the same cytological localization as cholinesterase, such as cysteine, methionine or glutathione. The role taken by these —SH compounds in the synthesis of acetylcholine and in the transmission of impulses may offer an explanation for the myoneural–synaptical localization of the reaction.

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Failure of the Agglutination Test to identify Types of *Pasteurella multocida*

A number of different serological methods have been employed for the identification of types within the species *Pasteurella multocida*[1–3]. Three different serological types were identified by Little and Lyon[4] by means of a slide agglutination test. Their types 1, 2 and 3 were made available through the American Type Culture Collection. These and other types identified by Little and Lyon's technique have been employed in some recent studies on *P. multocida*[5–7]. It is the purpose of this communication to point out inadequacies of the agglutination test for the identification of serological types within this species.

Different types of *P. multocida* can be recognized by an indirect hæmagglutination test[8,9] in which the specific capsular substance is employed as antigen and by mouse protection tests in mice[10]. The results of the hæmagglutination test concur with those obtained with the serum protection tests.

A large number of slide and tube agglutination tests have been carried out with a variety of strains of *P. multocida* over a number of years. It has not been possible to identify types with any degree of confidence by the agglutination reaction. Two of the reasons for the deficiency of these tests are cited below.

Many capsulated strains of *P. multocida*, particularly freshly isolated strains, are inagglutinable in low dilutions of their homologous immune sera, although they may give reactions as high as 1 : 320 and 1 : 640 in the hæmagglutination test. The A.T.C.C. strain No. 6535 (type 3) was negative to all four type sera in the tube agglutination test. The A.T.C.C. strain No. 6530 (type 2) was agglutinated only partially by types *A* and *B* antisera.

Many non-capsulated strains of *P. multocida* produce smooth colonies and possess high mouse virulence. In a previous study these cultures were referred to as colonially smooth but antigenically rough. Among these cultures are many that clump to a varying degree in the presence of sodium chloride. The difficulty of carrying out satisfactory agglutination tests with these cultures has been referred to[3]. The A.T.C.C. strain No. 7707 (type 1) was so sensitive to salt that the majority of organisms settled out of saline in less than 24 hr.

Because of inagglutinability due to capsulation, and spontaneous clumping in the presence of sodium chloride, I have found the agglutination tests to be unreliable in the identification of serological types. Until the difficulties cited above have been circumvented, it is recommended that the use of the serological classification of Little and Lyon be suspended.

The perpetuation of an unsound serological classification will only contribute to confusion in an already complex and little-understood species. For example, the conclusions reached in a recent study[11] of *P. multocida* will remain in question as long as there is doubt regarding the identification of the type strains employed.

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Lingering Effects of Local X-Irradiation on Healing of Burns

X-rays delay the healing of thermal burns and other injuries[1–4]. What is not well known is how long the inhibitory action of X-rays lasts. The present experiment was designed to determine the length of time this inhibitory effect persists in a locally irradiated area so as to retard the healing of subsequent thermal burns.

X-ray doses of 1,600 and 2,400 r. were used, and the thermal burns inflicted immediately and one, two and three weeks after irradiation. Doses lower than 1,600 r. produced either inconsistent or no effects on burn healing. Ten rats weighing 250–350 gm. were used for each condition; there being 80 in the whole experiment. 2,000 kVp. X-rays were administered at a rate of 600 r./min. to an area on the flank and upper hind leg in a half-moon shape 1 in. in diameter. The remainder of the body was shielded from the radiation by 4 in. of lead. The animals were lightly anæsthetized with nembutal. One day before the irradiation the area was freed of hair by clippers followed by a depilatory lotion and washing. Animals were burned with a heated copper brand (200° C.) in the form of three parallel lines (1/32 in. wide, 1 in. long and 3/16 in. apart) placed on the skin for 1 sec. so that one-half of all three branding lines were in the irradiated area and the other half of the three brands in the adjacent non-irradiated area. Daily observations for differences in the healing of these

Table 1. The Number of Rats showing Retarded Healing of Burns in an Area of Skin Irradiated with 1,600 and 2,400 r.

Time thermal burn given after X-rays (weeks)	No. of rats	Days after branding 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total observed differences
		1,600 r.																				
0	10	0	0	0	0	2	2	4	7	10	6	4	2	2	3	4	3	3	1	0	0	53
1	10	0	0	0	0	2	5	7	9	8	7	4	2	1	1	1	1	0	0	0	0	48
2	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2,400 r.																				
0	10	0	0	0	0	0	3	5	8	10	10	9	8	6	6	5	4	2	1	1	1*	79
1	10	0	3	4	6	8	7	3	3	5	7	6	6	5	5	5	5	3	1	0	0	82
2	10	0	0	0	0	0	0	0	0	1	2	2	2	2	1	0	0	0	0	0	0	10
3	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

* 0 at 21 days

burns in the two areas were made over a 20-day period for each animal and for each brand separately.

The degree of healing in both the X-irradiated and non-irradiated burned areas was determined using as criteria the degree of inflammation, width of the brands, and presence of scar tissue. In no case did the burns heal more quickly in the irradiated area.

Healing was retarded when branding was done up to one week after irradiation with 1,600 r.; but not when done two and three weeks later (Table 1). With 2,400 r., retardation was observed with animals branded up to two weeks after irradiation, although this represented only a small proportion of the animals branded. These lingering effects seemed to coincide with the length of time that erythema caused by the X-irradiation itself was visible.

Although there was only a slight difference between 1,600 and 2,400 r. with respect to the lingering effect of radiation, there was a pronounced difference in intensity of the injury. This is indicated by the number of cumulative healing differences recorded during a 20-day period following branding which was greater with 2,400 r. than with 1,600 r. (Table 1). In addition the proportion of brands (there being three brands per animal) on individual rats showing retarded healing was twice as large with 2,400 r. as with 1,600 r.

Where retardation of the healing of burns was observed, the maximum difference in healing under most conditions was observed 8–10 days after the burns were inflicted. This coincided with complete healing of the burns on the non-irradiated area of skin. In Table 1, therefore, the period of time in which differences were recorded represents the healing time of burns on the irradiated side. This latter is 16–20 days or about twice the time taken for healing on the control side. This is similar to that recorded by Hawkins and Clark[1] using suberythemal doses of X-rays and heat. Merwin and Hill[4] using a different criterion of healing found that the revascularization of small burns, which were inflicted immediately after irradiation, was retarded about four times the normal period (7 days) with doses of 1,500 r.

In one case where the thermal burns were inflicted one week after 2,400 r., two maxima of healing difference were observed, at 5 days and 10 days after branding. The second maximum was due to recurrence of differences already recorded in the 5-day maximum. It is assumed that this effect resulted from varied rates of healing among the three brands.

We conclude that X-rays do not retard the healing of burns inflicted beyond one to two weeks after irradiation with the doses used and that radiation effects, when present, delay healing to twice its normal time.

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Effect of Gibberellic Acid on the Growth of Protonemata in *Splachnum ampullaceum* (L.) Hedw.

Stowe and Yamaki[1] wrote, in a recent review, of the work on the physiological action of the gibberillins: "Reminiscent of the auxins, no convincing action of the gibberillins has yet been shown on any organisms except higher plants". In the course of studies on protonematal regeneration and growth in the moss *Splachnum ampullaceum* (L.) Hedw., the effect of gibberellic acid on the growth of the protonemata was also tested.

Leaves of comparable age and position in the gametophore were isolated and planted under sterile conditions on Beijerinck's inorganic medium with 1 per cent agar. They were kept under artificial illumination with fluorescent (day-light) lamps. The chemical, which was obtained from the Nutritional Biochemical Corporation, Cleveland, Ohio, contains the potassium salt of gibberellic acid at 7·2 per cent. The protonemata regenerating from the isolated leaf tend to grow radially from the leaf, so that the tips of the protonemata form a circle around the leaf (Fig. 1). The radius of this circle formed by the longest protonemata was taken as a measure of protonematal length. Measurements of protonematal length were taken one month after planting.

Table 1 and Fig. 1 show the influence of gibberellic acid on protonematal growth. To establish the relative contribution of cell division compared with cell enlargement in this increase in the length of the protonemata, the following ratios were used:

$$\frac{\text{Radius of system at 1,000 } \mu\text{gm./ml.}}{\text{Radius of system at 0·0 } \mu\text{gm./ml.}} = \frac{6·981}{1·152} = 6·07$$

and

$$\frac{\text{Cell length at 1,000 } \mu\text{gm./ml.}}{\text{Cell length at 0·0 } \mu\text{gm./ml.}} = \frac{0·1116}{0·0477} = 2·34$$

Table 1

	Control	Amount of 7·2 per cent gibberellic acid used			
		1 μgm./ml.	100 μgm./ml.	500 μgm./ml.	1,000 μgm./ml.
Length of protonemata (mm.)	1·152	1·069	3·161	5·680	6·981
Cell length (mm.)	0·0477	0·0376	0·0739	0·0977	0·1116
Cell width (mm.)	0·0192	0·0186	0·0172	0·0170	0·0165

The difference between these two ratios indicates that the growth-promoting effect of gibberellic acid on the protonemata is brought about both by an increase in the number of cells and the size of the cells. While the length of the cells increased greatly with an increase in the concentration of gibberellic acid, cell width decreased slightly.

It was observed earlier that the presence of fungal contaminants in cultures containing protonemata greatly increased the growth of these protonemata. To determine the specificity of this 'fungal effect', cultures of isolated leaves of the moss, growing on Beijerinck's inorganic medium, were inoculated with various fungi, obtained from airborne fungal spores. The different fungi had a rather similar growth-promoting effect on the protonemata. The 'fungal effect' was therefore an unspecific one obtainable with a variety of different fungi.

An attempt was made to duplicate this effect by means of the addition of different individual amino-acids and vitamins and various combinations of them, including also various concentrations of yeast extract and casein hydrolysate, to the inorganic medium in the absence of the fungus. In no case was there any marked increase in the growth of the protonemata. A complete series of concentrations of indole-acetic acid showed similarly that the latter does not have any growth-promoting effect on the protonemata. With the exception of the great similarity between the effect of gibberellic acid and the 'fungal effect' on the growth of protonemata, it was not possible, therefore, to replace the 'fungal effect' by means of any of the other compounds tested. Although it seems established that gibberellic acid has to be considered as a growth-promoting factor for the protonemata of *Splachnum ampullaceum*, the unspecificity of the 'fungal effect' makes the similarity between this effect and that of gibberellic acid difficult to explain.

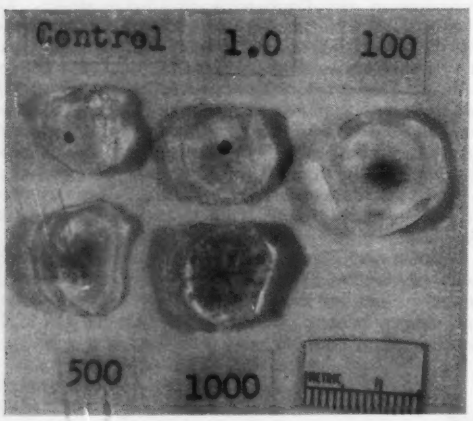

Fig. 1. Effect of gibberellic acid on the length of protonemata (1 month after planting)

It should be mentioned that Sironval[2] reported that gametophyte development in *Funaria hygrometrica* passes through three distinct stages: chloronema → caulonema → gametophore. He states that with low light intensities, in which the chloronema → caulonema transition does not take place, this transition can be brought about in the presence of *Penicillium*. Protonemata developed by way of regeneration have, according to Sironval[2], always the characteristics of caulonema. Hence both 'fungal effect' and the growth-promoting action of gibberellic acid should be an effect on caulonematal growth if Sironval's developmental scheme applies also to *Splachnum*. Although we have no material for comparing chloronema with caulonema in *Splachnum*, our regeneration protonemata do not show the characteristics which Sironval describes as being typical for caulonema (see also ref. 4). We can therefore only speak in terms of the effect of gibberellic acid on the growth of protonemata rather than of its effect on caulonemata in *Splachnum ampullaceum*.

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Effect of Anaerobic Conditions on Imbibed Lettuce Seeds

In investigations into the influence of soil conditions on the establishment of vegetable crops from seed, experiments on the effect of the atmosphere on seed germination have shown that seeds of lettuce (*Lactuca sativa* L., var. Cobham Green) are capable of germinating, though not of growing rapidly, when exposed to an atmosphere of 80 per cent nitrogen, 5 per cent oxygen and 15 per cent carbon dioxide. Published evidence[1,2] suggests that concentrations of carbon dioxide in the surface layers of cultivated soils are rarely, if ever, higher than 4 per cent, and it might be assumed that any effect of soil anaerobiosis on crop plants is due to lack of oxygen rather than excess of carbon dioxide. However, Hack[3] has pointed out that the smaller the sample of soil air taken, generally the higher is its carbon dioxide content.

To test the respective effects of a deficiency of oxygen and an excess of carbon dioxide, seeds were allowed to imbibe in air for various periods, then exposed to atmospheres of nitrogen or carbon dioxide for 1 or 2 weeks, during which time no seeds germinated, and then returned to air and maintained until no further germination occurred. Moisture was non-limiting throughout. Some of the effects on lettuce seeds at 18 ± 2° C. are shown in Table 1.

Anaerobic treatment for one week in nitrogen after 0–12 hr. or in carbon dioxide after 0–6 hr. imbibition in air did not affect germination capacity, but there was an abrupt reduction in the proportion of seeds surviving the carbon dioxide treatment following 12 hr. as compared with 6 hr. imbibition, suggesting a

Table 1. Percentage Germination on Returning Seeds to Air

Prior imbibition in air (hr.)	Nitrogen		Carbon dioxide	
	7 days	14 days	7 days	14 days
0	86	32	80	5
6	70	40	80	10
12	87	2	20	2

The interaction of prior imbibition period × gas × anaerobic period was highly significant ($P < 0.01$).

specific effect of carbon dioxide from a certain stage of seed activation onwards. In this connexion, Bendall *et al.*[3], working with germinating seeds of *Ricinus*, have recently shown how concentrations of carbon dioxide of more than 20 per cent can affect respiration by interfering with the mitochondrial redox system of cytochrome *c*. In the experiment described here, non-germination after carbon dioxide treatment was accompanied by excessive swelling of the seed and necrosis of the unemerged radicle. In the few affected seeds which escaped microbial invasion, all the organs, except the root, emerged after some delay and grew normally. All seeds not surviving the nitrogen treatment softened and disintegrated completely.

Lettuce seeds with blackened radicles are frequently found in seed boxes in which the soil has been too wet. In view of the present results, this is circumstantial evidence for the existence of high concentrations of carbon dioxide even in shallow layers of soil; although these may be confined to conditions where the carbon dioxide produced, for example, by the respiration of seeds in the initial stages of germination, cannot escape rapidly from its source of origin.

Full details of these investigations will be published elsewhere.

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Chloride Effect on the Growth of *Chlorella pyrenoidosa*

A chloride (anion) effect has been reported for washed chloroplasts[1] and for lyophilized *Chlorella* cells[2]. Recently there has been evidence reported to show that chlorine is a micronutrient element[3]. No definite growth requirement by freshwater algae for chloride has yet been shown. The purpose of this communication is to report that, with certain media, the growth of *Chlorella pyrenoidosa* is appreciably increased by the addition of chloride. Furthermore, stimulation by sodium has also been observed.

A special medium for *Chlorella* was formulated on the basis of the critical concentrations of nutrients for autotrophic growth[4]. The critical concentration of a nutrient element is defined as the minimum amount of the element which will produce maximum growth. The special medium had, in addition to the usual amount of iron (as sulphate) and trace elements (manganese, copper and zinc as sulphates): 1.8×10^{-4} *M* KH_2PO_4, 25 mgm./l.; 1.95×10^{-4} *M* K_2SO_4, 34 mgm./l.; 1.25×10^{-2} *M* $Mg(NO_3)_2.6H_2O$, 3,200 mgm./l. All the elements in the special medium were approximately at the critical concentration except that magnesium was ten times more concentrated.

Table 1. Comparative Growth of *Chlorella pyrenoidosa* in the Special Medium and in the Special Medium with Various Anion Supplements

Medium	Relative yield* (per cent)
Warburg and Burk (with sodium chloride)	100
Warburg and Burk (without sodium chloride)	102
Special	25
Special + 500 mgm. $MgSO_4.7H_2O$/100 ml.	64
Special + 250 mgm. KH_2PO_4/100 ml.	84
Special + 200 mgm. sodium chloride/100 ml.	122
Special + 352 mgm. sodium bromide/100 ml.	100
Special + 144 mgm. sodium fluoride/100 ml.	21
Special + 513 mgm. sodium iodide/100 ml.	4

* Based on packed cell volume

The special medium was found to be seriously inadequate (Table 1). The growth of *Chlorella pyrenoidosa* in the special medium was only 25 per cent of its growth in the regular Warburg and Burk medium[5]. The cultures were bubbled with 5 per cent carbon dioxide in air, were kept at a temperature of 25° C., and were illuminated with about 1,000 ft. c. of fluorescent light. In an attempt to improve the growth of *Chlorella*, in the special medium, separate additions of magnesium sulphate, potassium dihydrogen phosphate and sodium chloride were made to successive aliquots of medium in such a way as to make the nutrient the same strength as in the Warburg and Burk medium. Each of the nutrients improved the growth of *Chlorella*, but the greatest improvement occurred with the addition of sodium chloride. Afterwards, it was shown that sodium bromide was almost as effective as sodium chloride, and that sodium fluoride and sodium iodide were quite ineffective. The Warburg and Burk medium has consistently shown no difference in the yield of *Chlorella pyrenoidosa* with or without the addition of sodium chloride to the medium. The improvement of the special medium was really an anion effect rather than a specific chloride effect, inasmuch as growth was stimulated by sulphate and phosphate as well as by chloride.

A logarithmic gradient of sodium chloride concentrations superimposed upon the special medium showed: (1) that the amount of growth of *Chlorella* could be doubled with the addition of merely 0·02 mgm./100 ml. (3.4×10^{-6} *M*); (2) that the critical concentration for sodium chloride was about 200 mgm./100 ml. (3.4×10^{-3} *M*); (3) that the optimum additions of sodium chloride produced a medium which was fully 25 per cent better than the Warburg and Burk medium.

The role of sodium in the growth of *Chlorella pyrenoidosa* seemed to have been ruled out when it was found that a supplement of 250 mgm. sodium dihydrogen phosphate/100 ml. special medium produced a growth increase of only 40 per cent in contrast to the 400 per cent increase produced by 200 mgm. sodium chloride/100 ml. special medium. However, it became quite puzzling when equimolar potassium chloride (255 mgm./100 ml.) brought about increases of no more than 150 per cent.

A medium was formulated whereby it was possible to investigate the effect of sodium on the autotrophic growth of *Chlorella pyrenoidosa*. 2,550 mgm. potassium chloride/l. were added to the special medium in

order to produce full chloride stimulation, and a gradient of concentrations of sodium chloride was then superimposed upon this modified medium. The critical concentration for sodium was found to be $3{\cdot}4 \times 10^{-3}$ *M*. Heterotrophic growth of *Chlorella pyrenoidosa* in the dark in the presence of 1 per cent dextrose did not show any requirement for either sodium or chloride. These effects of certain anions and sodium were restricted to autotrophic growth, and, therefore, may indicate their involvement in photosynthesis.

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Influence of Media on the Counts of *Clostridium butyricum* in Soils

Although the distribution of nitrogen-fixing *Clostridia* in soils is wide, difficulties are encountered with their quantitative estimation. Recently, Parker[1] suggested that the 'nitrogen-free' media normally used may be deficient in essential growth factors and also showed that other media could inhibit development, although the toxicity of the media could be neutralized by raw potato sap. The influence of media is further investigated in the present study using Taupo light sandy loam, a low-fertility pumice soil under tussock grassland from Waiouru, New Zealand, and also a typical starch-fermenting strain of *Clostridium butyricum* isolated from this soil and shown to fix 4 mgm. nitrogen per gm. glucose utilized in the enriched media afterwards described.

The basal medium used had the following composition: K_2HPO_4, 1 gm.; $MgSO_4.7H_2O$, 1 gm.; $FeCl_3.6H_2O$, 10 mgm.; $ZnSO_4.7H_2O$, 1 mgm.; $Na_2MoO_4.2H_2O$, 0·5 mgm.; glucose, 10 gm.; agar, 15 gm.; tap water, 1 l. Soil extracts were obtained by autoclaving (15 lb./in.^{2} for 1 hr.) top soil with twice the quantity of tap water. The Egmont brown loam used for medium enrichment is a high-fertility volcanic soil from Hawera, New Zealand. Raw potato sap was prepared by homogenizing surface-sterilized peeled potatoes under aseptic conditions with an equal weight of water, centrifuging the resulting homogenate and storing the extract at − 20°. Soil extracts (10 per cent, v/v) were added to the medium before sterilization, but the potato extract (3 per cent, v/v) was added immediately prior to pouring the sterile medium. Counts were made by a method similar to that of Swaby[2]. A layer of the medium (10 ml.) was allowed to set in a Petri dish (10 cm. diam.). The inoculum (1 ml.) was then added and mixed with 25 ml. of molten medium added at 45° or 100°. Plates were incubated in the anaerobic jar of McIntosh and Fildes[3] at 24–28° for 7 days. In estimating *Clostridium butyricum* in the soil only colonies staining blue-purple with aqueous iodine and showing gas production were counted.

Table 1. The Effect of Medium Enrichment on Counts of *Clostridium butyricum* in Soil

The top layer of medium was added at 45°. Counts are recorded as means with the range of counts given in parentheses.

Supplement to basal medium	Samples studied	*Clostridium butyricum*, organisms/gm. undried soil
None	10	131 (40–220)
Extract of Taupo light sandy loam	10	130 (80–220)
Extract of Egmont brown loam	5	431 (336–567)
Raw potato sap	5	384 (220–540)

With the pure culture of *Clostridium butyricum* no toxic effects from media, poured at 45°, were found as there was no difference in the counts ($22–25 \times 10^6$ organisms/ml.) in potato glucose agar and in the basal medium enriched with the above extracts. In estimating the numbers of *Clostridium butyricum* in the Taupo light sandy loam, the use of potato sap gave an appreciable increase in counts (Table 1).

However, this is obviously due to the provision of factors either essential or stimulatory for the growth of this organism, as the incorporation of the extract of the high-fertility Egmont soil results in a comparable increased count. Some enrichment of the basal medium appears to be essential if falsely low counts, particularly from soils of low fertility, are not to be obtained. In a liquid medium, Augier[4] found a soil extract to be indispensable for enumerating nitrogen-fixing *Clostridia*, and from Table 1 it is clear that extracts should not be obtained from soils of low fertility. The stimulatory effects of soil extracts for many soil bacteria is well known and for some Gram-negative bacteria has been suggested to be due to calcium[5]. The nature of the stimulatory factors in the present media has not been investigated.

By pouring media at 100° and at 40° to differentiate between spore and total counts, Swaby[2] concluded that in Victorian soils *Clostridium butyricum* existed chiefly as spores. A similar result was obtained with the Taupo light sandy loam, the count of *Clostridium butyricum* in this soil in medium poured at 100° being 90 per cent of that in medium poured at 45°. It has now been established, however, that these techniques do not distinguish between spores and vegetative cells (Table 2).

With a culture of *Clostridium butyricum* containing less than 1 per cent of spores, colonies from the hot medium were sometimes smaller and produced less gas than those from the cooler medium. The final count, however, was not appreciably affected, particularly if a longer incubation period was used. The results of Swaby[2] and those from the Taupo soil can be explained, therefore, by a lag in

Table 2. Influence of Temperature of Medium on Counts of *Clostridium butyricum*

The inoculum of *Clostridium butyricum* was prepared from a culture in potato glucose medium. The medium for counts was enriched with the extract of the Egmont soil.

Experiment No.	Incubation period (days)	Viable count, organisms × 10^6/ml. Medium poured at :	
		45°	100°
1	5	2·0	2·0
2	6	3·0	1·7
2	10	2·9	2·8

the multiplication of vegetative cells and not by their destruction in media poured at 100°.

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Maleic Hydrazide in the Control of the Bulbous Weed *Oxalis pes-caprae*

A NUMBER of reports have appeared in the literature to the effect that preharvest application of maleic hydrazide to the foliage of plants like potatoes[1,2,4], carrots[3], onions[3,4,6], and sugar beets[4,5] inhibited subsequent sprouting during storage or in the field. With this information at hand a preliminary study was carried out in order to test the possibilities of using maleic hydrazide in the control of the bulbous weed *Oxalis pes-caprae*, which has proved resistant to herbicides of the 2,4-dichlorophenoxyacetic acid type.

The bulbs of *O. pes-caprae* are usually distributed from soil surface to a depth of 12–18 in., the plants emerge above surface in April and die off completely by the beginning of summer in October, leaving behind the new generation of bulbs. These bulbs start sprouting in February, but growth is very slow until the first rains in April.

Potted plants of *O. pes-caprae*, started from bulbs, were sprayed with 0·15 per cent and 1·5 per cent maleic hydrazide (percentage concentration of active ingredient in water plus detergent) to run off on four different dates. In November the bulbs produced by these plants were counted and then planted back into pots (about ½ in. below surface) in order to observe their sprouting behaviour. The number of bulbs produced by the treated plants and the percentage of final sprouting are indicated in Table 1.

Table 1

Date of treatment	Concentration of maleic hydrazide (per cent) 0·15		1·5	
	No. of bulbs per 15 plants	Total sprouting (per cent)	No. of bulbs per 15 plants	Total sprouting (per cent)
May 5	66	100	51	35
June 7	64	62	23	0
July 3	89	35	108	10
September 5	111	62	118	13
Control	90	100	90	100

These results indicate that at both maleic hydrazide concentrations there is a reduction in the number of bulbs produced after an early treatment, the effect being more pronounced in the higher concentration. Late treatment does not reduce the number of bulbs. This can be explained by considering the developmental stage of the plant at the treatment times. Generally, bulb production starts towards the end of June; in consequence maleic hydrazide sprayed before that stage may, by virtue of its antimitotic action[7,8] and general retardation of the growth of the plant, interfere with the formation of these bulbs. From July onwards, when the bulbs are in the process of enlargement, application of maleic hydrazide does not affect the number but reduces the size and at the higher concentrations may result in deformed bulbs.

However, from the practical point of view the reduction in bulb numbers is not so significant as the long-term effect of maleic hydrazide on the sprouting of the bulbs; all treatments, with the exception of the earliest application of 0·15 per cent, had a definite inhibitory effect on sprouting which was particularly pronounced in the three later applications of 1·5 per cent maleic hydrazide. A number of the bulbs which sprouted developed abnormally shaped shoots with atypical scale-like leaves; some of these eventually recovered and produced normal rosettes with trifoliate leaves. The bulbs which did not sprout perished in the soil by the end of winter.

Large-scale field trials have been laid out in order to assess the practicability of using maleic hydrazide in the control of *O. pes-caprae* in heavily infested land. In view of the rather high concentrations of maleic hydrazide necessary for a satisfactory inhibition of sprouting, it is doubtful whether it could be used as a selective herbicide concurrently with the growth of crops or pastures, although it may prove valuable as a pre-sowing treatment.

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Heterogeneity of *R*-Enzyme

Hobson, Whelan and Peat[1] showed that *R*-enzyme preparations from broad beans and from potatoes brought about the following changes in the properties of amylopectin: (*a*) an increase in the capacity to combine with iodine as reflected in the blue value[2]; (*b*) a reduction in the viscosity of solutions; (*c*) an enhanced susceptibility to β-amylolysis. Such preparations were also found by Whelan *et al.*[3,4] to catalyse the hydrolysis of the 1 : 6-glucosidic bonds of the limit dextrins produced by the action of salivary α-amylase on amylopectin.

Recent separations of the enzymes of malted barley by chromatography on alumina led to the detection by Harris, MacWilliam and Phillips[5] of a number of components of which one, while resembling *R*-enzyme in its attack on amylopectin, differed from it in failing to act on the above-mentioned limit dextrins. On the other hand, another component brought about the rapid hydrolysis of limit dextrins in the same manner as the *R*-enzyme preparations studied by Whelan *et al.*[3,4] but, by contrast, was without apparent action on amylopectin.

It has now been shown that when preparations of *R*-enzyme, obtained from broad beans by the method of Hobson *et al.*[1], are similarly chromatographed on alumina, two separate active fractions are obtained.

As in the case of the enzymes of malt, one component attacks amylopectin with concomitant increase in blue value but lacks the ability to cleave limit dextrins, while the second fails to affect amylopectin but causes rapid hydrolysis of the branched dextrins.

The separation of two enzymic activities from preparations of *R*-enzyme proves that the latter is itself a mixture. This finding raises the question of the nomenclature of the individual enzymes from all the sources examined. It seems reasonable to retain the term *R*-enzyme for the component attacking amylopectin, while the second component may well be identical with that already termed limit dextrinase[4-6]. It is perhaps surprising that *R*-enzyme fails to attack the α-1 : 6-linkages of limit dextrins, while the evidence advanced by Hobson *et al.*[1] suggests that it can hydrolyse such linkages in the larger substrate, amylopectin. Further investigations to elucidate the mode of action of the enzyme are in hand.

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Fate of Spores of *Trichoderma viride* Pers. ex Fr. introduced into Soil

In the course of an ecological study of *Trichoderma viride* Pers. ex Fr., observations have been made on the survival and germination of its conidia and chlamydospores in soil. Comparatively few direct studies on the behaviour of fungal spores added to soil have been recorded. Dobbs and Hinson[1], Chinn[2] and others[3] have demonstrated in short-term experiments that when the spores of most fungi tested, including *Trichoderma*, were placed in natural unamended soil they failed to germinate, although germination followed by early lysis of the germ tubes was noted in a restricted number of species. Park[4] did not observe germination of conidia of *Trichoderma* or spores of five other species of fungi placed on the surface of natural soil and commented on the rapid digestion of the majority of them. On the other hand, Legge[5] found that oospores of *Phytophthora* spp. survived burial in the soil for one year, and numerous workers have shown indirectly that pathogenic fungi may persist in soil for long periods.

In the present work, the technique using glass-fibre threads[5] has been followed with minor modifications. Sterilized 10-cm. lengths were placed on plates of a standard nutrient agar and these inoculated with isolates of *Trichoderma viride*. After incubation at room temperature in the light for one month the threads were lifted and buried singly 1 in. below the surface of unsterilized soil in 3-in. pots. At various intervals threads were removed, stained in phenolic rose-bengal[6] and examined immediately. In some cases portions of the threads were cut off before staining, gently washed in sterile water and placed in Weindling's solution or on an agar medium as an additional test for viability of spores and to attempt recovery of the fungus.

Table 1. Survival of Spores of *Trichoderma viride* in Soil

Time in soil	Estimates of spore frequency on threads	
	Conidia	Chlamydospores
Nil	++++	+++++
20 weeks in *B*1 horizon beech-wood soil	++	++++
1 year in garden soil outdoors	0 to +	+ to +++
1 year 8 months in garden soil in greenhouse	0 to +	+
1 year 8 months in *A* horizon beechwood soil in greenhouse	0 to +	++

+, Rare; ++, occasional; +++, frequent; ++++, abundant; +++++, profuse.

In one experiment the pots were filled with soil from the *A* horizon of a clay-loam garden soil (*p*H 7·0) and afterwards sunk to the brim outdoors in the same soil. Threads were recovered in this case for examination and re-isolation of the fungus after one year. In further experiments, pots supplied with this soil and others with soils from the *A* and *B*1 horizons of a beech wood (*p*H 5·0) were kept freely watered in a cold greenhouse. Threads were removed at regular intervals up to 20 weeks and then after various periods up to 1 year 8 months.

The technique used enabled observations to be made of large numbers of conidia and chlamydospores interspersed among the individual fibres of the threads. Different isolates of the fungus showed only minor variations in behaviour. In Table 1 the survival results for one strain only, at the termination of the experiments, are summarized. While there was a progressive breakdown of both conidia and chlamydospores in the soil, nevertheless some survived the longest periods of burial which have so far been used.

Chlamydospores proved more resistant than conidia, but that even very small numbers of the latter should survive such periods in soil is of interest. Tests of viability of the spores in Weindling's medium after lying in garden soil for one year were positive, and isolates of the fungus obtained from portions of the threads transferred to agar showed the same cultural characteristics as the original put into the soil. This was also the case with re-isolations from threads after 1 year 8 months in both types of soil. Some hyphæ but no spores were seen on uninoculated threads used as controls in the experiments.

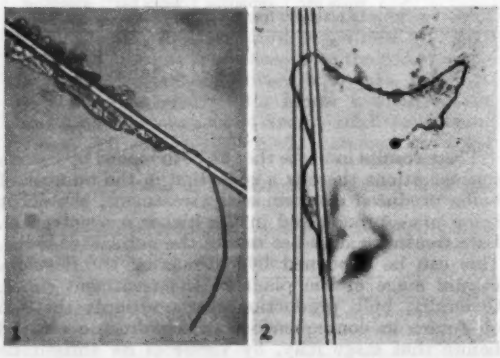

Fig. 1. Conidium of *Trichoderma viride* germinating in garden soil after 12 weeks. (× 270)
Fig. 2. Chlamydospore of *Trichoderma viride* germinating in garden soil after 1 year. (× 270)

Both conidia and chlamydospores were also observed germinating while still enmeshed in the threads after burial in all three soils for varying lengths of time. Examples on threads from garden soil after 12 weeks and 1 year are shown in Figs. 1 and 2. These instances were not of frequent occurrence, and the number of spores germinating was estimated always to be less than 1 per cent of those dormant. The stimulus to germinate could have been due to changes in the microhabitat of the spore, but this explanation is less easy to accept where only a single spore of a compact group developed (Fig. 1). Inherent variations in spore structure and physiology may also be concerned.

These results show that in the soil types used, *Trichoderma viride* survives for considerable periods both as chlamydospores and conidia and that there is a low rate of germination of these spores. That this may result in colonization of suitable substrates was suggested by the presence of numerous very densely stained, and therefore presumably recently formed, chlamydospores in a piece of plant debris found attached to one of the threads. Long-term survival of other fungi in like manner is a possibility which accords with the demonstrations by Warcup[7] that the majority of colonies developing on soil-dilution plates arise from spores.

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Stipe Regeneration and Fruit-body Production in *Collybia velutipes* (Curt.) Fr.

During the course of genetical studies on the basidiomycete *Collybia velutipes* it was desirable to have sufficient numbers of fruit-bodies for tetrad analysis, random basidiospore platings and cytological investigations. By utilizing the stipes of this fungus, we were successful in evolving a technique which decreases the time necessary for fruiting, increases the yield of fruit-bodies and involves little preparation and incubation space.

A mycelial inoculation of a wild-type dicaryon, or its two component monocaryons, on 20 ml. of 2 per cent malt agar in a 150-ml. conical flask generally yields fruit-bodies after 25–35 days when incubated at 19 ± 1·5° C. and kept under constant illumination[1,2]. We found that if the stipes from these fruit-bodies are placed on malt medium in a Petri dish and incubated under the same conditions of temperature and illumination as above then new fruit-bodies of similar size may be formed after 10–13 days. They arise from primordia which appear on the surface of the stipe (Fig. 1*a*). The development of these can occur anywhere on the stipe, but they usually form on the cut ends; the number produced has been found to vary between 10 and 123 per 1 in. of stipe. Successful fruit-body production will occur from a piece of stipe as small as 0·5 cm. long and approximately 2·5 mm. in diameter.

a *b*

Fig. 1

The time taken to form mature fruit-bodies by both the normal inoculation and the 'stipe' method varies according to the strain used. Both morphological and auxotrophic mutant strains, originally derived from the wild-type strain, generally take up to 40 days to fruit by the former and up to 20 days by the latter method.

When the stipes of fruit-bodies which arise from stipes are themselves plated, normal fruit-bodies are again formed. We have found that normal fruiting still occurs after five such successive platings; but the time taken to produce fruit-bodies progressively increases from 10 days for the first to 17 days for the fifth plating.

The amount of mycelium growing from stipes used as inocula varies considerably between platings even when similar lengths of the same stipe are used. So far we have been unable to correlate mycelial production with the time taken for the stipe to produce mature fruit-bodies. In one experiment, in which 2-cm. lengths of the same stipe were plated singly on each of four dishes, all fruited in 12 days, but the amount of mycelium produced by individual stipes varied considerably; in another similar experiment those stipes producing the least amount of mycelium fruited up to 4 days before those producing the most. Occasionally, mycelium completely envelops the stipe; in our experience no fruit-bodies are ever formed when this happens.

Stipes placed on 1·5 per cent non-nutrient agar produce primordia which develop into fruit-bodies with barrel-shaped stipes approximately 3 mm. long bearing a minute pileus devoid of basidiospores.

These results suggest that not only are nutrients essential for the formation of fruit-bodies from stipes but also that a fruit-body inducing substance(s) may be involved. The stipe tissues appear to be determined in their development, since when a stipe homogenate is plated fruit-bodies are formed 5–10 days sooner than from a plating of homogenized mycelium. Since fragments of successive generations of stipe continue to form fruit-bodies it seems likely that a fruit-body inducing substance(s) is formed continually and more rapidly by stipe tissue than vegetative mycelium. That such a substance may be built up gradually as the mycelium ages is suggested by the results of experiments in which flasks of malt medium inoculated with mycelium (together with the underlying agar) from stock culture 2–3 weeks old generally formed fruit-bodies only at the point of inoculation (Fig. 1*b*). So far, attempts to isolate a cell-free extract containing a fruit-body inducing substance have been unsuccessful.

A more detailed account of this work will be published elsewhere. One of us (R. F. O. K.) is

indebted to the Department of Scientific and Industrial Research for a research studentship.

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A Soil-borne Virus associated with the Corky Ringspot Disease of Potato

A sap-transmissible rod-shaped virus which is carried in the soil has been recovered from corky ringspot-affected Sebago potato tubers and from a certain percentage of potato plants produced from diseased tubers. The virus has also been recovered from systemically infected potato seedlings, pepper and tobacco when these plants were grown in the greenhouse in virus-containing loamy fine sand soil, obtained from the site of field infection in northern Florida.

The virus has been named the 'potato corky ringspot virus' (*PCRV*) and is distinguished readily from potato viruses *A*, *F*, *M*, *S*, *X* and *Y*. A relationship between it and the soil-borne potato stem-mottle, and tobacco rattle viruses from the Netherlands, has been established serologically. Because it is associated with symptoms in potato tubers differing from those reported for the latter two viruses, the above specific name has been applied. Precipitation with 50 per cent saturated ammonium sulphate did not cause a decrease in infectivity of new virus. The virus was infective in undiluted tobacco sap heated for 10 min. at 80° C., but not in sap heated at 90° C.

The exact relationship between a virus isolated from corky ringspot diseased potato tubers, first reported in 1946 [1] from the potato-growing area of Hastings, Florida, and a soil-borne virus isolated from systemically infected potato seedlings, is being examined. Reports of a type of corky ringspot of potato tubers from Indiana and Washington are also being investigated.

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Bugula simplex Hincks, a Newly Recognized Polyzoan from British Waters

In September 1957, a species of *Bugula* was discovered at Holyhead, North Wales, which did not conform to any of the species described by Hincks[1]. Reference to the literature showed that it resembled the *B. flabellata* of American authors, although it was, in fact, clearly not *B. flabellata* (Thompson). Osburn[2] identified the American form as *B. flabellata* and noted that Woods Hole material did not conform completely to the description given by Hincks[1], although he evidently did not appreciate the full extent of the differences. Since the species is common in the Woods Hole area on submerged piles[2] and has been the subject of extensive experiments, notably by Lynch[3], its proper identification is of importance.

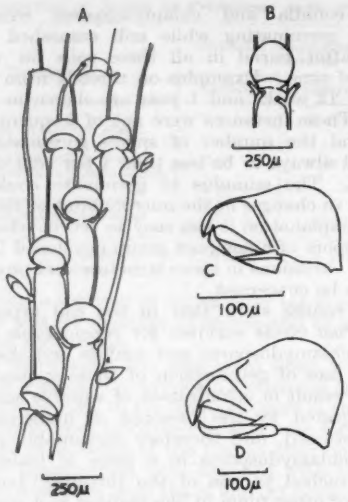

Fig. 1. *A*, *Bugula simplex*, portion of branch showing hemispherical ovicells and single spines on zoœcial angles; *B*, *B. flabellata*, distal end of zoœcium showing globular ovicell and two spines on each zoœcial angle; *C*, avicularium of *B. simplex*; *D*, avicularium from marginal zoœcium of *B. flabellata*

Hastings (private communication) told me that the British Museum (Natural History) had specimens of this type sent by Verrill from North America, and also from Lowestoft, which were probably the same as *B. sabatieri* Calvet[4]; further, *B. sabatieri* might be a synonym of *B. simplex* Hincks[5]. No type specimen of *B. sabatieri* has been seen, but Calvet's description closely fits the form being discussed, which is, however, identical with the type of *B. simplex*. As the latter name has priority the species must be called *B. simplex* Hincks.

Descriptions of *B. simplex* are given by Hincks[5], Calvet[4] (as *B. sabatieri*) and Osburn[2] (as *B. flabellata*). A description of true *B. flabellata* is given by Hincks[1]. In fact, although both species have zoœcia arranged in several rows, *B. simplex* is readily distinguishable from *B. flabellata* (Fig. 1).

The most obvious diagnostic characters of *B. simplex* are: the almost hemispherical oœcia; the restriction of the avicularia to the marginal series of zoœcia; and the presence of only one, less often two, spines on each of the distal angles of the zoœcia. In *B. flabellata* the oœcia are almost globular; avicularia are present on both the inner and the marginal series of zoœcia, although the former are much smaller than the latter; and the number of spines on each distal angle is two, or three on the outer angles of the marginal series of zoœcia. The avicularia of *B. simplex* are quite characteristic in shape, with a rather long head and a down-curved beak, although these points are not brought out in Calvet's[4] figure.

Specimens of *B. simplex* in the British Museum (Natural History) have been obtained from the Adriatic (type specimen), the British Isles (Lowestoft) and the Atlantic coast of North America (Woods Hole and Noank, Conn.). As the specimen from Lowestoft was collected from the lifeboat in 1893, or earlier, there can be no question of the species being a recent introduction to Britain. As *B. sabatieri* the species has been recorded from the Mediterranean coast of France[4].

The larvæ of *B. simplex*, according to Calvet[4], have eight orange pigment spots. American larvæ, however, have none[3]. Larvæ liberated by Holyhead specimens showed considerable variation in the development of pigment spots, but usually possessed four faint spots that could readily be overlooked. Thus the development of pigment spots may be a character which is subject to geographical variation, and certainly requires further investigation.

A new account of the British species of *Bugula*, including *B. simplex* and other species not mentioned by Hincks[1], is in course of preparation.

I should like to thank Dr. A. B. Hastings for making her notes on this subject available to me and for enabling me to examine specimens in the British Museum.

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An Effect of the Uterine Environment upon Skeletal Morphology in the Mouse

The classical demonstration of a maternal effect in a mammal is Walton and Hammond's[1] series of crosses between Shire horses and Shetland ponies. Shire mares inseminated with Shetland sperm produced foals which at birth were nearly three times the size of foals born from the reciprocal cross. A difference between reciprocal hybrids was still apparent in adult life.

An earlier observation on equid hybrids[2] is directly relevant to the work to be described. The cross between the horse, which normally has six lumbar vertebræ, and the ass which has five, is said to give hybrids which differ in this, as in some other characters, according to the maternal species used: the mule more nearly resembles the horse, and the hinny the ass.

A maternal effect which is manifest at birth must act through one of three possible pathways. (1) The chromosomes: whereas daughters receive one *X*-chromosome from the mother and one *X*-chromosome from the father, sons receive only one *X*-chromosome, and this they derive from the mother. Consequently any difference between reciprocal hybrids attributable to *X*-borne genes (such as the hæmophilia gene in man) can be described as a maternal effect manifest only in the male progeny. The phenomenon is more usually described by the term 'sex linkage'. Any maternal effect manifest in the *female* progeny must act through one or other of the two remaining pathways, namely, (2) the egg cytoplasm, or (3) the uterine environment.

Experimental discrimination between (2) and (3) can be achieved by the transfer of eggs from one parental strain to uterine foster-mothers of the other strain. If the transfer has no influence on the character under study, then the egg cytoplasm must be responsible for the maternal effect; if it has an influence, the uterine environment is implicated. By these means Venge[3] was able to demonstrate a uterine basis for a maternal effect on weight at birth of rabbits.

With a character so plainly susceptible to nutritional factors as weight at birth, a uterine rather than a cytoplasmic mechanism might seem *a priori* more likely. We have been concerned[4,5] with a less obviously 'nutritional' character, namely, the number of lumbar vertebræ in mice. In some inbred strains this number is predominantly 5 and in others 6. Green and Russell[6] showed a difference in the direction of the maternal strain between reciprocal hybrids of the *C3H/Bi* strain (5 lumbar vertebræ) and the *C57BL* strain (6 lumbar vertebræ). Various experiments on other combinations of strains intended to distinguish between cytoplasmic and uterine pathways have failed to be conclusive. Thus, Russell[7] found that offspring from transplanted ovaries showed an effect of the host upon vertebral type. Such offspring are of course gestated in the uterus of the host; but the cytoplasm of the eggs from which they are derived has also been elaborated from host materials. Hence the result is equally compatible with a cytoplasmic effect. Egg-transfer experiments[8] suggest a uterine effect, but analysis shows that they fall short of statistical significance.

We have confirmed the difference in skeletal type between reciprocal hybrids[5], and by means of egg transfer we have now shown that the effect is uterine. Our technique for transferring fertilized mouse eggs has been described previously[9].

Three kinds of mice were raised in parallel over a period of 27 months. The vertebral types of the three groups of mice are shown in Table 1. We emphasize the following features of our evidence: (1) female mice only are described here, thus excluding any effects attributable to sex linkage. (2) The three sets of results were collected over the same period of time. This precaution was necessary to control the possibility of a secular drift in one or both of the strains used[4]. (3) On the right-hand side of Table 1, litters are tabulated separately according to the 'majority vote' of their members. To count each mouse separately, as is done on the left-hand side of Table 1, may give a misleading impression of the weight of the evidence unless allowance is made for correlation between litter-mates.

To discriminate between the cytoplasmic and uterine pathways we need to decide whether the mice in the bottom row of the table resemble those in the top row, with which they have their uterine history in common, or those in the middle row, with which they have their cytoplasmic history in common. Obviously they resemble the former and differ from the latter. A weighted analysis of variance

Table 1. Vertebral Types of Three Groups of Mice (Females Only)

(Each mouse has either five or six lumbar vertebræ, or is asymmetrical, that is, the sixth lumbar vertebra is sacralized on one side only)

	Individual mice				Litters		
	5	Asymmetrical	6	Total	Majority with five lumbar vertebræ	Others	Total
C57BL ♀ × *C3H* ♂	16	11	34	61	6	20	26
C3H ♀ × *C57BL* ♂	30	11	8	49	15	9	24
C3H ♀ × *C57BL* ♂ (eggs transferred to *C57BL* uteri)	7	4	19	30	4	15	19

shows that the results summarized in rows 2 and 3 differ at the 0·1 per cent level of probability. The maternal effect (responsible for the difference between rows 1 and 2) is therefore uterine. The alternative (in our opinion, remote) possibility that the transfer operation itself has had a non-specific effect upon vertebral type is under test. Preliminary results tell against this hypothesis.

Deol and Truslove[10] find that some skeletal characters are correlated with weight at birth, and hence are presumably nutritionally controlled, and that others are not. In extensive material we find no relation between vertebral type and litter size, a variable on which weight at birth is known to be strongly dependent. This confirms a similar finding of Green and Green[11], who showed in addition that vertebral type was unrelated to adult body-size. Evidently the vertebral character which we have studied is not 'nutritional' in any simple sense, and hence the uterine influence must be a more subtle matter than the mere quantity of food supplied to the embryo.

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High Chiasma Frequency in Allocyclic Segments of Chromosomes

In *Agriotes mancus* Say, an elaterid beetle, two pairs of autosomes are distinctly longer than the rest of the chromosomes. In spermatogenesis these long, metacentric autosomes—here labelled L_1 and L_2—form bivalents which are easily recognizable during the mid-diplotenic – diakinetic stages by differences in their longitudinal structure. There are three kinds of allocyclic segments in these chromosomes, all of them negatively heteropycnotic: the unstainable procentric segment in both L_1 and L_2; a similar, but interstitial segment in L_2; and a third, less allocyclic segment between the other two in L_2.

Only very seldom is more than one chiasmata formed in the bivalents of this species[1,2]. In order to study the position and terminalization of the single chiasma in L_1 and L_2, about seventy males were collected in November 1955, in Hall's Harbour, Nova Scotia, and studied during the winter months in the Forest Insect Laboratory, Sault Ste. Marie, Ontario. The beetles were kept at a temperature of 3° C., in a metal box with a little moist earth in it. Cold storage arrests the spermatogenetic process, keeping the cytological picture of the testes virtually unchanged for at least five months. It results, however, in minor

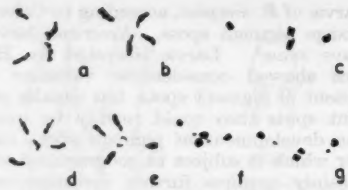

Fig. 1. Diakinetic L-bivalents; *a–c*: L_1; *d–g*: L_2 (every lettered figure shows one bivalent with its long, unstainable gaps). *a*, *b*, *d* and *e* from early diakinesis, *c*, *f* and *g* from mid-diakinesis; all from one and the same individual. Chiasma in the understained segment in *d* and *e*, in the distal gap in *g*, and in the procentric gap in *f*

changes in the nucleinization and spiralization of the chromosomes. In *Agriotes mancus* the allocyclic segments were the most affected and the unstainable segments especially were very long. In addition, a difference in contraction was often recognizable between the euchromatic arms, particularly in L_1, where the shorter arm was often more compact than the longer one. Fig. 1 illustrates the diakinetic appearance of the L-bivalents with the chiasma in an allocyclic segment.

As described in greater detail elsewhere[2], the terminalization of the chiasmata of the L-bivalents is a very slow process prior to late diakinesis. This concerns especially the proximally located chiasmata. Therefore, all observations prior to the stage of '8 microns' (the stage in late diakinesis, when the total euchromatic length of L_1 had contracted to 8μ) were dealt with together. A simplified scheme of the distribution of the single chiasma in a sample of 1,160 spermatocytes appears in Fig. 2. The main chiasma frequencies for both arms have been counted from a smaller sample of late bivalents with completed terminalization of the chiasma.

The most remarkable result of this analysis is the discovery that more than one-fifth of all chiasmata are formed in the absolutely heteropycnotic gaps, or at their borders. Furthermore, the two gaps of L_2 are involved with almost equal frequency, with the procentric one slightly less often (5 : 6, according to a small sample of 60 cells). The understained segment between the two gaps of L_2 is also frequently involved in relation to its length. This frequency could not be determined for the whole material, but a sample of 290 mid-diakinetic nuclei gives a percentage as high as 42·2.

These results strongly suggest a special readiness of the negatively heteropycnotic segments to form chiasmata, as reported in certain other test objects earlier (cf. Barton[3], Wolf[4]). A comparison between L_1 and L_2 further shows that the location of

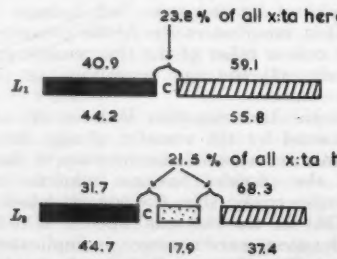

Fig. 2. Distribution of the single chiasma in L_1 and L_2, according to 1,160 diplotenic–diakinetic nuclei. Main frequencies for both arms above, relative lengths of stainable blocks below. *c*, Procentric gap

a proximal chiasma is determined rather by the degree of nucleinization or spiralization than by the proximity to the centromere: in other words, the less the contraction of a segment, the higher the probability of a chiasma in it. This relation even seems to extend, although perhaps not significantly, to the euchromatic blocks: the chiasma is more commonly found in the less-condensed euchromatic arm.

The intricacy of the case of *Agriotes* becomes evident when an explanation is attempted in terms of the localization theory based on initiation and the time-limit of pairing[5–7]. According to this theory, the position of a localized chiasma is highly dependent on the initiation point of pairing. In cases of zygotenic bouquet polarization, a more or less distal location is to be expected, because the pairing is considered to initiate from polarized ends. In *Agriotes*, however, the only chiasma tends to have a proximal location, although a neat bouquet exists in the prophase. Consequently, it would appear that the pairing starts so late that in many cases only the negatively allocyclic proximal segments are still capable of breaking and chiasma formation. No evidence of this has been found, however. A 'pre-bouquet' initiation of pairing cannot therefore be excluded as a possible explanation. If the proximal chromosome parts have been brought close together in the preceding anaphase, conjugation presumably starts proximally, and independently of bouquet formation. In the Coleoptera, at least, according to my observations, a strong heteropycnosis develops immediately after the last spermatogonial anaphase, causing intense stainability in the very young spermatocytes. Sticky masses of chromatin maintain the close juxtaposition of the proximal chromosome parts, and would thus facilitate any trends towards proximal initiation of pairing.

Whatever the chief reason for the preferred proximal location may be, it is clear that it must coincide with a special capacity for chiasma formation in the allocyclic segments.

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Deoxyribonucleic Acid Side-Chain Model of the Chromosomes

At the 1954 Oak Ridge Symposium on Genetic Recombination, I proposed a model of the chromosome in which the molecules of deoxyribonucleic acid projected as side-chains from the main protein axis of the chromosome[1]. The advantages of such a model for explaining the results of cross-over studies involving closely linked markers were briefly discussed at one of the sessions of the 1956 Cold Spring Harbor Symposium on Genetic Mechanism. In this model, the genes (deoxyribonucleic acid) are linearly arranged along the chromosome; however, the linearity within the gene is not continuous with, or a part of, the linearity between genes. Intergenic cross-overs would be of the classical type involving exchanges of whole segments of the chromosome, whereas intragenic cross-overs would not exchange other markers on the chromosome. According to this conception, the chromosome is composed of alternate sections of deoxyribonucleic acid and protein. To satisfy the requirement for chromosomal continuity it was suggested that the two chains of the Watson–Crick deoxyribonucleic acid double helix are tied together at the free end. Taylor[2] has published a chromosome model that differs from mine in that the chromosomal elements are tied together at the other end of the deoxyribonucleic acid instead by making the backbone continuous. In this communication I propose to consider three lines of evidence that may serve to distinguish between these two models.

In the original model, chromosome continuity involves both the deoxyribonucleic acid and the protein, whereas in Taylor's model the continuity lies only in the backbone. Stadler and Uber[3], as well as Kirby-Smith and Craig[4], have shown that the action spectrum for chromosome-breakage by ultra-violet light is almost identical with the nucleic acid absorption curve. Since a direct test showed no detectable transfer of ultra-violet light energy from nucleic acids[5], it is difficult to escape the conclusion that the ultra-violet-induced chromosome aberrations result from breakage in the deoxyribonucleic acid or at the point of attachment of the acid to the protein. This favours a model in which the acid is a part of the chromosomal continuity.

The mechanism and consequences of duplication are dependent on the position at which the chromosome elements are tied together in the model. According to my model, the result of chromosome duplication is the original and a completely new chromatin thread. Duplication according to Taylor's modification results in two daughter chromatin threads, each of which is half old and half new. The incorporation experiments of Taylor, Woods and Hughes[6] with tritium-labelled thymidine showed that the root-tip somatic chromosome is composed of two units that separate at duplication, with the result that each daughter chromosome is composed of an original and a new unit. To conform with this result, Schwartz's model requires that the chromosome be composed of half-chromatids that separate at duplication. In Taylor's model, the two units are the two chains of the deoxyribonucleic acid helix; thus the chromosome must be composed of only a single chromatin thread before duplication since, in the second duplication after incorporation of labelled thymidine, a non-labelled chromosome is produced (Fig. 1*a*). If the preduplication chromosome is already doubled, that is, composed of two half-chromatids, the Taylor model will not fit. The data would require that duplication of each half-chromatid results in the original and a completely new half-chromatid, as would occur from duplication according to our model (Fig. 1*b*). There is extensive literature supporting the half-chromatid nature of the somatic chromosome. The evidence includes cytological observations of the chromatid split at anaphase and telophase[7–10] and of half-chromatid aberrations[11–13].

Taylor[14] has presented evidence for a differential polarity in the "two strands of the chromosomal duplex". This evidence is based on the frequency of twin exchanges where two of the four homologous

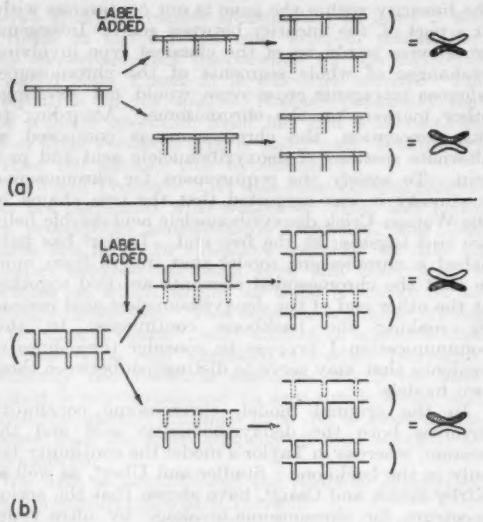

Fig. 1. Diagrammatic representation of chromosome duplication according to Taylor's (*a*) and Schwartz's (*b*) models. For simplicity, the deoxyribonucleic acid side-chains are drawn uncoiled. The results of the labelling experiments require that, according to Taylor's model, the preduplication chromosome be single, whereas Schwartz's model requires that the chromosome be composed of half-chromatids. The brackets encompass individual chromatids. The labelled units are represented by broken lines and stippling

chromosomes in the second c-mitosis after labelling show sister chromatid exchanges at the same level. These exchanges involve whole chromosomal segments, and hence, on Taylor's model, could result only from exchanges in the backbone. Thus the polarity responsible for the restrictions in rejoining of broken chromatids cannot be equivalent to the polarity in the deoxyribonucleic acid double helixes that comprise the side-chains. On the other hand, in my model at certain stages in replication (Fig. 4*d* of ref. 1) the linearity of the acid is a part of the linearity of the entire chromosome, and exchanges in the acid would result in exchanges of whole chromosomal segments.

I believe that the points raised in this communication favour my side-chain model of the chromosome over Taylor's modification.

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Sex Chromatin in Polyploid Nuclei of Human Amnion Epithelium

In previous reports from this laboratory it was noted that two or more sex chromatin bodies are present in some female nuclei, particularly in those from amnion epithelium[1–3]. Barr and Moore[4] found multiple sex chromatin in some nuclei from malignant tumours and suggested that this is due to hyperploidy. Myers[5] described multiple sex chromatin in teratomas. Atkin[6] found that 7 out of 65 malignant tumours from females had two sex chromatin-like bodies per nucleus. He assumed that these nuclei were tetraploid and confirmed this with the aid of chromosome counts and estimations of deoxyribonucleic acid. It was of interest to determine if in non-pathological tissue the female nuclei in which we had found more than one sex chromatin body were of a polyploid nature and whether the occasional sex chromatin-like structure in male nuclei could be correlated with polyploidy.

The amnion from 6 embryos (56–200 mm. crown-rump length) were removed at operation, fixed in 95 per cent alcohol and stained according to a standardized Feulgen procedure described elsewhere[1,7]. In the 6 amnia (3 from males and 3 from females) a total of 320 nuclei (30–90 nuclei per amnion) and their sex chromatin bodies were measured histophotometrically for deoxyribonucleic acid content. The deoxyribonucleic acid values are expressed in terms of an arbitrary index. Further details concerning the photometric technique and error factors, as well as the theoretical justification of our method, will be discussed in a forthcoming paper. All factors considered, the method gives reliable qualitative results. Although we obtained consistent results in all our determinations, our conclusions are based only on comparative values within each preparation.

Fig. 1 shows different types of nuclei found in amnion epithelium. Fig. 2 is a histogram from one female amnion preparation which is typical for our series. It can be seen that the nuclei fall into distinct groups according to their arbitrary deoxyribonucleic acid index. The numerical distribution of the nuclear types is not indicative of their actual distribution since polyploid nuclei were selected in order that a sufficient number could be measured. The first group represents the diploid nuclei ($2n$); the second group with approximately double the deoxyribonucleic acid value represents the tetraploid class ($4n$). In addition to the $2n$ and $4n$ classes there is a small group the ratio of which of (4 : 1) with the $2n$ class would place it in the $8n$ category. Such nuclei were found in all our preparations. Occasionally nuclei were found the deoxyribonucleic acid values of which would mark them as $3n$ and $6n$ (rarely in some preparations as $12n$ and $16n$). Because of the limited number of our measurements we cannot decide if the last four categories really exist. In our material the nuclear area alone gave no reliable indication of polyploidy.

In the female almost all the $2n$ nuclei have one sex chromatin body (Fig. 1*a*). In the $4n$ group the nuclei either have two distinct sex chromatin bodies, each with the same deoxyribonucleic acid index as those in the $2n$ group (Fig. 1*b*), or have one sex chromatin body which has a deoxyribonucleic acid index twice as high as the $2n$ sex chromatin body (Fig. 1*c*). Female nuclei with $8n$ values have 2–4 sex chromatin bodies the deoxyribonucleic acid sum of which is approximately four times the value of $2n$ sex chromatin bodies.

Fig. 1*d* shows a 16-ploid female nucleus with four double-value sex chromatin bodies. The double-value sex chromatin body usually appears as if it were larger and/or more densely stained than the sex chromatin body of 2*n* nuclei. The direct visual estimation of the sex chromatin is not accurate because it is dependent on its spatial orientation, whereas this factor does not influence the photometric reading. Male nuclei of the 2*n* class sometimes have a minute chromatin mass against the nuclear membrane which cannot be measured accurately. In the male 4*n* and larger polyploid classes, a chromatin mass which is not associated with the nucleolus chromatin could sometimes be found. These masses are usually not well delineated, seldom against the nuclear membrane and very rarely show the bipartite form. (It has been shown that the sex chromatin in diploid female nuclei often can be resolved into two components. This is the bipartite form[3].) In general, the male sex chromatin-like mass in polyploid nuclei has a deoxyribonucleic acid index less than the average female 2*n* sex chromatin body. Even 8*n* or higher class male nuclei were sometimes without any mass of chromatin similar to a female sex chromatin body (Fig. 1*e*). It must be pointed out that in these polyploid nuclei the chromatin is densely packed together because the chromatin content is increased several fold often without a proportionate increase in volume. This makes the identification of the sex chromatin more difficult. Yet, since the increase in density resulting from polyploidy is the same in male and female nuclei, one would expect to be able to recognize female type sex chromatin in male polyploid nuclei if it were present in the same form.

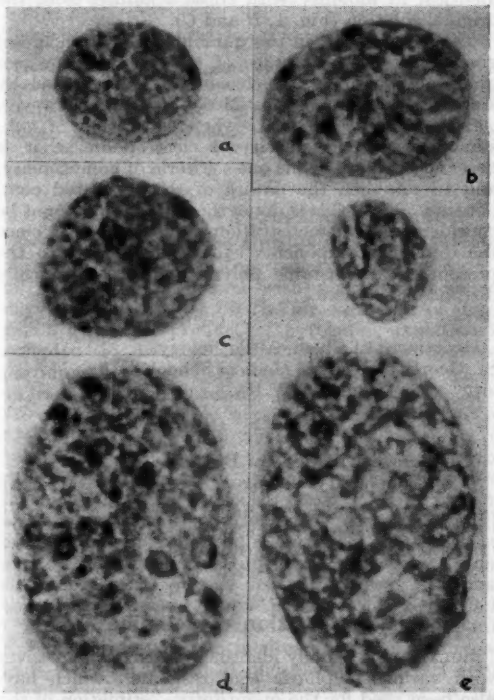

Fig. 1. Nuclei from amnion epithelium, *a–d* from a 67-mm. female and *e* from a 64-mm. male embryo. Feulgen method. *a*, Diploid female nucleus with a single sex chromatin; *b*, tetraploid female nucleus with two single sex chromatins; *c*, tetraploid female nucleus with a double value sex chromatin; *d*, 16-ploid female nucleus with four double value sex chromatins; *e*, (top), diploid male nucleus without sex chromatin; (bottom) 16-ploid male nucleus with small chromatin granules but without sex chromatin-like bodies. (× 3,200)

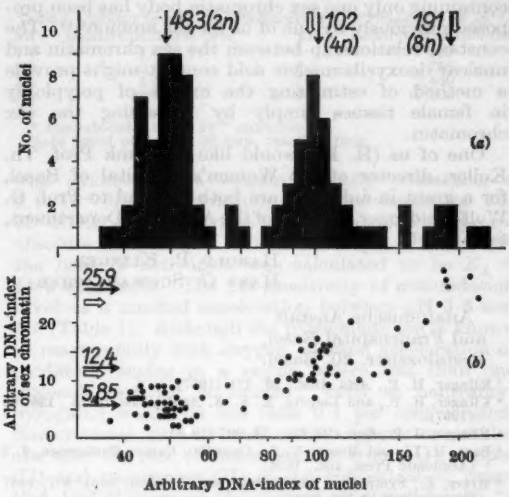

Fig. 2. *a*, Sample histogram of nuclear deoxyribonucleic acid values. Ninety nuclei from amnion epithelium from a 56-mm. female human embryo. *b*, Relationship between the sex chromatin and the nuclear deoxyribonucleic acid content. Each point represents the total deoxyribonucleic acid value of the sex chromatin body or bodies of the corresponding nuclei from diagram *a*. ↓ and →, mean values of the groups; open arrows, multiples of the mean value of the first group (2*n*)

Our observations show that the female polyploid nuclei have sex chromatin bodies the total deoxyribonucleic acid values of which indicate that with each additional diploid chromosomal compliment another sex chromatin mass is added. These findings support the theory that the sex chromatin is the result of the heterochromatic portions of the *X* chromosomes[1,2,3,9]. If two *X* chromosomes are capable of forming a sex chromatin body on the female nucleus, then in polyploid male nuclei where two or more *X* chromosomes (and *Y*'s as well) are present, one might expect to find a female-type sex chromatin. This, however, does not always seem to be the case. Several theories may be proposed to explain these findings. It is possible that the *Y* chromosome, being paired with the *X* chromosome, in some way inhibits the two heterochromatic portions of the *X* chromosomes from combining to form a sex chromatin body. Or, more simply, the two or more heterochromatic portions of the *X* chromosomes of a polyploid nucleus would combine if they came in contact with each other. Such a combination may be purely a matter of chance and could explain the occasional sex chromatin-like structures in male nuclei.

While preparing this paper it came to our attention that Bassermann[10] has found multiple sex chromatin in some nuclei of the ciliated bronchial epithelium. Although he made no photometric measurements, it is quite apparent from his description and photographs that his assumption that these nuclei are polyploid is correct. His results are therefore in agreement with ours in regard to female nuclei. He did not examine male tissues so that in this respect no comparison can be made. His suggestion that polyploid nuclei can go on to divide amitotically, and thus cause multinucleated cells with each nucleus

containing only one sex chromatin body has been proposed previously by one of us for the amnion[1,11]. The constant relationship between the sex chromatin and nuclear deoxyribonucleic acid content might provide a method of estimating the extent of polyploidy in female tissues simply by inspecting the sex chromatin.

One of us (H. K.) would like to thank Prof. Th. Koller, director of the Women's Hospital of Basel, for a grant-in-aid. We are both grateful to Prof. G. Wolf-Heidegger, director of the Anatomy Department, for his help.

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Separation of Metastable Polymers by Starch Gel Electrophoresis

Starch gel electrophoresis, as developed by Smithies[1,2], is a delicate method for the separation of large, charged molecules. By this means, serum proteins have been separated into a great number of components, which presumably are more homogeneous than the five or six groups obtained by the usual methods of zone electrophoresis. Nevertheless, it is important to realize that different components separated from a mixture by means of starch gel electrophoresis may contain different polymers of a monomer, and thus may not be as different as the clear-cut separation might suggest. The following example illustrates this point.

During our work on the dye uptake of serum proteins, we noticed that the quinoid form of bromocresol green (tetrabromo-*m*-cresol sulphonphthalein) appeared to be polymerized. Thus in dialysis experiments on the acid side of the *pK* of the dye (4·7), when it is mostly in the phenolic form, equilibrium was reached usually within two days, whereas, in similar experiments on the alkaline side, when the dye is predominantly in the quinoid form, equilibrium was not fully attained until after two weeks.

The sample of bromocresol green used was subjected to analysis in two different chromatographic systems[3], and also by paper electrophoresis at *p*H 8·5, and, by these criteria, was found to be about 98 per cent pure. On electrophoresis in starch gel, however, the quinoid form of this dye split up into two distinct components (Fig. 1, *A*). The conditions of electrophoresis were essentially those described by Smithies for the analysis of serum proteins, and can be summarized as follows: the concentration of partially hydrolysed starch gel was 14 gm./100 ml. in a solution of *p*H 8·5 containing 0·05 *M* boric acid and 0·02 *M* sodium hydroxide; the bridge solution contained 0·3 *M* boric acid and 0·06 *M* sodium hydroxide; a potential difference of about 5 V./cm. was applied across the gel for 5·5 hr. at room temperature, giving an average current of about 1·4 m.amp./cm. width of gel.

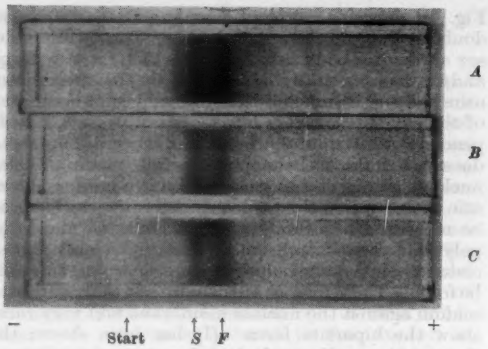

Fig. 1. Starch gel electrophoresis of bromocresol green at *p*H 8·5. *A*, Original solution splitting into slow (*S*) and fast (*F*) components; *B*, second electrophoresis of eluate of slow component from (*A*); *C*, second electrophoresis of eluate of fast component from (*A*)

Colorimetry of eluates of these two components showed that the bromocresol green had split into roughly equal parts. These eluates were dried, and were subjected again to starch gel electrophoresis. Each of the original single bands, both the fast and the slow, split into two colorimetrically equal bands, identical in mobility with those obtained from the original solution (Fig. 1, *B* and *C*).

This shows that, in the quinoid form, bromocresol green exists as a mixture of two polymers or two groups of polymers, which can be distinguished by starch gel electrophoresis. More important, however, is that it indicates that, when separation of substances occurs in starch gel electrophoresis, it is necessary both to define one's criteria of homogeneity, and to establish the nature of the separated components. Until this is done, the separation cannot be considered as a demonstration of heterogeneity, since the different components can be due either to the presence of metastable polymers, or to chemically distinct substances.

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Identification of Solanine

Solanine is usually identified by the colours given with various sulphuric acid reagents[1], which have also been used for the quantitative estimation of this alkaloid[2–4]. These sulphuric acid reagents, although suitable for identification or determination of the pure alkaloid from potatoes, with the crude substance extracted from viscera give rise to considerable charring, which makes identification difficult and estimation almost impossible.

This charring may be avoided by the substitution of phosphoric acid for the sulphuric acid in the Marquis reagent. It has been found that a 1 per cent solution of paraformaldehyde in 90 per cent phosphoric acid gives a deep steel-blue colour with solanine, as little as 1 μgm. being readily detectable by the microtechnique described by Clarke and Williams[5]. The reagent may also be used to develop spots of solanine on a paper chromatogram.

The test has a high degree of specificity. Of 300 alkaloids, natural and synthetic, that have been tested, only α-chaconine and solanidine give identical shades, and even here the colour with the latter alkaloid is initially more purple. Deserpidine, yohimbine and pseudoyohimbine give a colour that is at first similar, but which rapidly fades to a pale grey. Tomatine and demissine give a faint blue-grey. Of the others, medrylamine, colchicine, demecolcine and piperine give a bright yellow; thebaine, ergocristine, ergotamine, propantheline and the 6-methoxy-8-aminoquinoline derivatives such as pentaquine give an orange colour; while such phenothiazine derivatives as chlorpromazine give varying shades of purple. Microgram quantities of the other alkaloids tested give no colour.

I am most grateful to Dr. R. K. McKie and Messrs. L. Light and Co. for gifts of alkaloids.

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Autoxidation of Pyrogallol: General Characteristics and Inhibition by Catalase

During a study of the oxidative polymerization of phenols[1], experiments with phenolic monomers included observations on the air oxidation of pyrogallol. The end-product of pyrogallol oxidation is accepted to be the hydroxylated benztropolone, purpurogallin[2], which is characterized by two ultraviolet absorption maxima, 270–275 mμ and 310–320 mμ and a visible maximum in the region of 425 mμ. We have found that purpurogallin is neither the sole nor the terminal product of pyrogallol oxidation, and it is not formed during slow oxidation in homogeneous systems. The present account describes some features of pyrogallol autoxidation reflecting upon the nature of the reaction, and on its biological significance as well, and constitutes in part, a basis for work now in progress on surface-directed polymerization of pyrogallol.

When 5×10^{-3} *M* pyrogallol (10 ml. vol. in 50-ml. Erlenmeyer flasks) was incubated with shaking at 26·0 ± 0·2° C. in 0·01 *M* phosphate buffer, *p*H 4·10, colour formation could be followed readily in the Beckman *DU* spectrophotometer at 425 mμ. The reaction was a linear function of time for several hours with $K_{1st\ order} = 8{\cdot}5 \times 10^{-5}$ sec.$^{-1}$.

From − 20° C. to + 98° C., autoxidation-rates increased 1·8–2·3 fold per 10° C. increment. Even at − 20° C., *p*H 4·12 (adjusted with hydrochloric acid), as much as 2×10^{-10} mole/min. of pyrogallol was oxidized in a system initially containing a 5×10^{-3} *M* concentration. In the region of 20–30° C., $\log K_{1st\ order}$ was a linear function of reciprocal absolute temperature. From the slope, $-3{\cdot}24 \times 10^3$, the heat of activation was calculated to be E_a = 14·8 kcal./mole. The *p*H sensitivity of autoxidation involves a marked acceleration between *p*H 3·5 and 4·5 (Table 1). Although the pyrogallate ion is known to react rapidly with oxygen, marked acceleration of oxidation begins in a region where less than one molecule per 10^6 is ionized; even at neutrality, pyrogallol would be less than 0·1 per cent ionized. Heavy-metal cations and small organic molecules can alter the rate of autoxidation. Iron (III), copper (II) and manganese (II) in the concentration range 10^{-6}–10^{-3} *M* increase the rate of oxidation by 50–75 per cent. Cobalt (II) inhibits it 10 per cent at 10^{-4} *M* and antagonizes enhancement by the manganous ion. Aluminium, zinc, cadmium and nickel were without effect. It has already been noted that the iron-catalysed peroxidation of pyrogallol is greatly enhanced by deoxyribonucleic acid and inhibited by methylcellulose, gelatin and other polymers[3].

Table 1. Effect of *p*H on Autoxidation of Pyrogallol at 26° C.

*p*H	Relative oxidation-rate	*p*H	Relative oxidation-rate
1·0	1·0	6·1	120
2·9	2·0	6·5	228
3·6	4·5	7·0	2,400
4·5	38*	8·8	12,000
4·9	61		

* Absolute-rate, $3{\cdot}1 \times 10^{-5}$ mole/min.
Rate based on initial 30 min. reaction time.

Apropos the reactions involved in autoxidation, the most informative experiments deal with inhibition by catalase (Table 2). This enzyme is operative at 10^{-6} *M* or less, from *p*H 4·1 to *p*H 8·8 but is most effective in the region of *p*H 4–6. The maximum inhibition effected by catalase in no case exceeded 86–89 per cent. Heat-denatured catalase (30 min. at 100° C.) is not inhibitory.

Table 2. Inhibition of Autoxidation by Catalase at *p*H 4·1

Catalase *M* × 10^{-6}	Percentage of Inhibition	Catalase *M* × 10^{-6}	Percentage of Inhibition
0	0	1·0	84
0·1	36	2·0	86
0·2	80	3·0	86

When concentrated peroxidase solution is added drop-wise to pyrogallol–hydrogen peroxide mixtures in acid media, there appears rapidly, but transitorily, a deep-pink intermediate the colour of which is readily discharged by ascorbic acid, thiols, and other antioxidants. Alternatively, the red substance may be accumulated briefly (15 sec. to 3 min.) by mixing peroxidase with pyrogallol–hydrogen peroxide solutions containing a pyrogallol concentration of the order of 10^{-5}–10^{-6} *M*. The red substance vanishes, presumably having given rise to the yellow-brown products which appear secondarily. The red compound is not evident when enzyme–peroxide solutions are mixed rapidly together with pyrogallol at concentrations of 10^{-4} or more.

Considering the behaviour of the related phenol, catechol, under oxidizing conditions, the red product noted here is likely to be hydroxyortho-quinone. Presumptive quinone formation, together with the great specificity of catalase toward hydrogen peroxide, suggest that autoxidation of pyrogallol both generates and consumes oxide. The formation of peroxide by autoxidation of guaiaconic acid (in ethanolic gum guaiac solution) has been described[3].

The autoxidation of pyrogallol could be accounted for by free-radical reactions. However, the *p*H sensitivity

exhibited, suggests the importance of ionic reactants. It is unlikely that the pyrogallate ion is itself involved in the acid oxidation.

It is of biological interest that polyphenols may constitute a source of hydrogen peroxide. Promotion of hydrogen peroxide production by manganese (II) and its inhibition by cobalt (II) are known in plant tissue systems which also require substituted phenols as co-factors[4,5]. Plants are particularly rich in polyphenols (tannin, flavonoids, etc.) and autoxidations may be part of the extensive array of aromatic oxidations associated with differentiation and senescence.

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Quantitative Paper Partition Chromatography of Sialic Acids

Recently, it has been obvious that in most biological materials N-acetylsialic acid (N-acetylneuraminic acid) and N-glycolloylsialic acid occur together. By the introduction of a micromethod for the determination of glycollic acid, Klenk and Uhlenbruck[1] have made possible the evaluation of the amount of N-glycolloylsialic acid in isolated sialic acids. In search of a more direct method, we tried partition chromatography, employing the solvent systems previously used for the separation of sialic acids but with unfavourable results[2,3]. As the pK_a of sialic acids are low, about pH 2·7, it is necessary to use rather a strong acid in the solvents to prevent the dissociation of the carboxylic group. Of the different acids tried, only trichloracetic acid and hydrochloric acid were suitable. On crystallization of the sialic acids we had observed that N-glycolloylsialic acid was much more insoluble in alcohols than N-acetylsialic acid. Therefore, we tried mixtures of alcohols with the acids mentioned above. The best results were obtained with n-butanol/n-propanol/0·1 N hydrochloric acid (1 : 2 : 1, v/v). In this solvent the R_F values were for N-acetylsialic acid 0·45, and for N-glycolloylsialic acid 0·34, on Whatman paper No. 1. The solvent system applied cannot be used for the separation of diacetylsialic acids and is unsuitable for the separation of free acids and the methyl esters of the sialic acids.

During quantitative chromatography the papers were washed with 0·1 N hydrochloric acid, distilled water and chloroform/methanol (2 : 1, v/v) in that order. After drying the papers, about 100 μgm. of sialic acids were spotted on the starting-line. At the ends of this line a reference mixture of the two sialic acids was introduced. The paper strips were usually run 18 hr. overnight. After drying the papers at room temperature, narrow strips containing the end spots were cut from the original paper sheet and the position of the sialic acids determined by spraying the strips with one of the following two reagents.

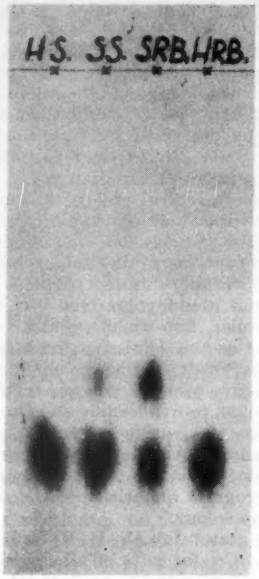

Fig. 1. Chromatogram of sialic acids from human serum (*HS*), sheep serum (*SS*), sheep red blood cells (*SRB*) and human red blood cells (*HRB*)

Resorcinol reagent: 1 gm. of resorcinol and 15 gm. of trichloracetic acid were dissolved in 20 ml. of ethanol/water (1 : 1, v/v) containing 0·2 ml. 0·1 M copper sulphate. The solution was diluted with 60 ml. n-butanol.

Ehrlich's reagent: 0·5 gm. of p-dimethylaminobenzaldehyde and 5 gm. of trichloracetic were dissolved in 20 ml. of ethanol/water and afterwards diluted with 60 ml. of n-butanol.

After spraying, the papers were heated at 100° C. for 10–15 min. With the resorcinol reagents the sialic acids gave brown–violet spots on a pink background and with Ehrlich's reagent N-acetylsialic acid gave a blue–violet spot and N-glycolloylsialic acid a red–violet spot on a yellow background. The spots of the methyl esters of the sialic acids were also red–violet.

The rest of the paper was divided into corresponding sialic acid zones by reference to the sprayed strips. At the same time, equal areas of paper were cut from the same major sheet to serve as paper blanks. The strips of paper cut out were divided in small pieces and put into centrifuge tubes. 5 ml. of distilled water was added and the tubes left for 2 hr. with occasional stirring with a glass rod. After centrifugation, 2 ml. of sialic acid solution was analysed by the resorcinol reaction. The accuracy of the method was ± 3 per cent.

Table 1

Source of sialic acid	Paper chromatography		Glycollic acid method	
	N-acetylsialic acid (per cent)	N-glycolloylsialic acid (per cent)	N-acetylsialic acid (per cent)	N-glycolloylsialic acid (per cent)
Human blood (serum and stroma)	100	0	100	0
Sheep serum	86	14	87	13
Sheep stroma	54	46	58	42

The method was adopted for the analysis of sialic acids in human and sheep serum and red blood cell stroma. As can be seen from Fig. 1, N-acetylsialic acid was the only visible acid in human blood, but in sheep blood both the sialic acids occurred. The amounts of the two sialic acids were determined by the procedure described and by the glycollic acid method.

As seen from Table 1 the agreement between the two methods was satisfactory. The much greater amount of N-glycolloylsialic acid in the red blood cell stroma than in the serum of sheep is noticeable, the reason for which is still unknown.

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A Survey of the Cosmic-Ray Nucleonic Component along 145° East Longitude using an Airborne Monitor

MANY reports have appeared in recent years of discrepancies between the observed distribution of cosmic ray intensity over the surface of the Earth and that expected from conventional geomagnetic theory. For example, the geomagnetic equator does not fit reported positions of equatorial cosmic ray minima[1] and a new cosmic ray equator must be determined by experiment. Furthermore, at intermediate latitudes direct measurements of low-rigidity cut-offs of alpha-particles and heavier nuclei frequently differ from those calculated from the Störmer theory using standard geomagnetic co-ordinates[2]. It appears that geomagnetic co-ordinates must be replaced by a new system of co-ordinates for the description of the Earth's effective magnetic field for cosmic rays.

In order to provide more information to assist in mapping the effective magnetic field, the University of Tasmania undertook a survey of the cosmic-ray nucleonic component between the longitude limits 140° E.–148° E. and extending from 52° S. to 34° N. geographic latitude. A two-counter neutron monitor of the type developed by Prof. Simpson of the University of Chicago was installed in a Lincoln bomber provided for the work by the Royal Australian Air Force. Separate electronic circuits were provided for each counter and scaled counts were accumulated on registers and recorded individually on a pen recorder. A specially calibrated altimeter was mounted with the registers and the register panel was photographed every 2 min. These records were supplemented by visual register and altimeter readings throughout the survey. The flights were made at a pressure altitude close to 20,000 ft. and the intensities were corrected for small departures from this altitude.

The present communication gives only a preliminary account of the results obtained. A more detailed paper will appear shortly.

The survey started at Melbourne (geographic co-ordinates 145° E., 38° S.) on July 18, 1957, and the northern limit (Tokyo, 140° E., 34° N.) was reached on July 24. Quiet cosmic-ray conditions

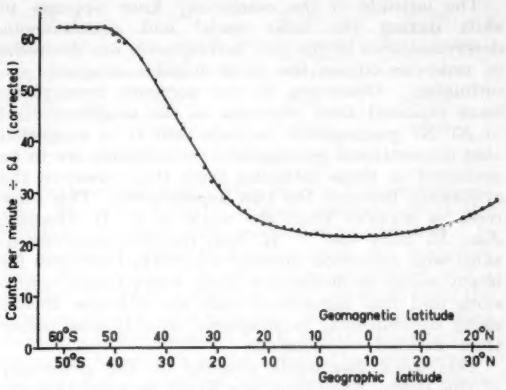

Fig. 1. The neutron monitor counting-rate, corrected for pressure and secular changes in the cosmic ray intensity, plotted against geomagnetic and geographic latitude for northbound flights only

prevailed during this period, and after small corrections for secular changes the results collected were used to locate the cosmic-ray equator. In Fig. 1 the observed intensity is plotted against geographic and geomagnetic latitude. It will be noted that the equatorial minimum is particularly broad and is symmetrical in the range 10° S.–26° N. A parabola was fitted to the curve within these limits, and the cosmic-ray equator was found from its minimum point. Outside these limits, however, a significant asymmetry is apparent. This is reduced but not eliminated when intensity is plotted against magnetic dip angle.

The cosmic-ray equator was crossed on the 145° E. longitude and was located at 7·1 ± 0·5° N. (95 per cent confidence limits). This can be compared with the following magnetic data, also for 145° E. longitude.

Geomagnetic equator	9·6° N. (geographic latitude)
Magnetic dip equator (ref. 3)	6·7° N.
Equator of dipole rotated 45° to west of geomagnetic dipole	2·1° N.

The magnetic dip equator appears to be strongly favoured for providing the best fit to the cosmic-ray equator, although the geomagnetic equator should not be ruled out until the present results are confirmed by an independent experiment. The departure from the equator of a dipole rotated 45° to the west of the geomagnetic dipole is, however, considerable, and the results must therefore be regarded as support for the suggestion by Rothwell and Quenby[4] that the cosmic-ray equator closely follows the dip equator rather than the rotated dipole equator proposed by Simpson.

The return flight from Tokyo commenced on July 30 and initially reproduced the results of the northbound flight. A delay at Momote (2° S.), however, resulted in the remainder of the flight being made shortly after the start of a Forbush decrease starting on August 4. This stage therefore provided an opportunity to study the dependence on latitude of the decrease. An account of this investigation will be given in a later paper.

To extend the survey over the south latitude knee a return flight was made on August 21 from Melbourne to 52° S. Intensity became independent of latitude above 43·5° S. on the longitude 148° E. Magnetic data corresponding to this location are:

Geomagnetic latitude	52·3° S.
Magnetic dip angle (ref. 3)	72·7°
Latitude for dipole rotated 45° to west of geomagnetic dipole	44·0° S.

The latitude of the cosmic-ray knee appears to shift during the solar cycle[5] and simultaneous determinations in the two hemispheres are desirable in order to choose the most suitable magnetic co-ordinates. Observers in the northern hemisphere have reported knee positions in the neighbourhood of 53° N. geomagnetic latitude and it is suggested that conventional geomagnetic co-ordinates are to be preferred at these latitudes since they preserve the symmetry between the two hemispheres. This view receives support from the work of V. D. Hopper, Jean E. Laby and Y. K. Lim (private communication) who measured directly the critical energies for heavy nuclei at Melbourne using water-loaded emulsions and find agreement with the Störmer theory using conventional geomagnetic co-ordinates rather than rotated co-ordinates.

This work was made possible by the generosity of the Royal Australian Air Force in providing the aircraft and accurate navigational information. Financial support was received in the form of a grant from the Australian Academy of Science.

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Auroral Absorption of 18-Mc./s. Cosmic Radio Waves on February 11, 1958

On the night of February 10–11, 1958, a spectacular auroral display was widely observed in the United States. Fig. 1 shows the effect of this aurora on 18-Mc./s. cosmic noise from the sky, as observed at the Sampson Station of this Observatory (lat. 42° 47′ N., long. 73° 27′ W.). The vertical scale indicates approximate relative absorption of cosmic noise in decibels as received. The horizontal scale gives Universal Time on February 11. The dotted line represents the record of the following night, February 12, which itself shows at 7hr. U.T. a characteristic dip which we consider to be associated with auroral activity. The peak at 0915 is a calibration mark. We note that the time marks, which are produced every 10 min. from *WWV* signals at 5 Mc./s., fade out at 0250 for the remainder of the night.

This record was obtained with an apparatus designed to detect sudden absorptions of cosmic noise as indirect indicators of solar flares. The antenna pattern covers most of the sky, with the gain greatest in the vertical direction. The receiver output depends on the minimum noise incident on the antenna as the frequency is swept over a range of 30 kc./s., to avoid interference by radio stations. The system is described briefly in *Astron. J.*, **62**, 243 (1957); a fuller description will be given in a forthcoming publication of this Observatory.

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Calculation of the Life-time of a Satellite

Three recent discussions of the effect of friction on a satellite[1–3] have been based on the assumptions (1) that the atmosphere is spherically symmetrical, (2) that SC_D is constant, where C_D is the drag coefficient and S the cross-sectional area perpendicular to the direction of motion, and (3) that the density of the atmosphere is exponential over the heights within which the perigee lies. The convenience of the third assumption is that the actual values of the density and the scale-height are not required, the mere constancy of the scale-height being sufficient. On the other hand, an elaboration of (3) requires a knowledge of the density distribution and is likely to lead to less rather than greater accuracy. The failure of (2) will presumably be a consequence of rotation of the satellite and will introduce periodic rather than progressive variations in the orbit. It seems that greater accuracy should be sought in correction for the lack of spherical symmetry of the atmosphere; this can be done with only a minor modification of the analysis of Scott[2].

The effect of the rotation and oblateness of the Earth is to introduce a first-order correction to the density distribution in the form:

$$\rho = \rho_0 \exp\left\{-\frac{z}{H} - \frac{\varepsilon R \sin^2\alpha \cos^2\theta}{H}\right\}$$

where ρ_0 is a constant, H the atmospheric scale-height, ε the ellipticity of the Earth, z the height above the surface of the Earth, R the radius of the Earth, α the inclination of the orbit to the plane of the equator and θ the angular distance from perigee in the plane of the orbit.

If we write the equation of the orbit in the form[4]:

$$r = p + A(1 - \cos\theta)$$

and carry through the analysis in the form used by Scott[2], we find that:

$$\left.\begin{aligned} \dot{p} &= -C \exp\left(-\frac{p}{H}\right)\left(\frac{A'}{H}\right)^{-3/2} \\ \dot{A}' &= -2C \exp\left(-\frac{p}{H}\right)\left(\frac{A'}{H}\right)^{-1/2} \end{aligned}\right\} \quad (1)$$

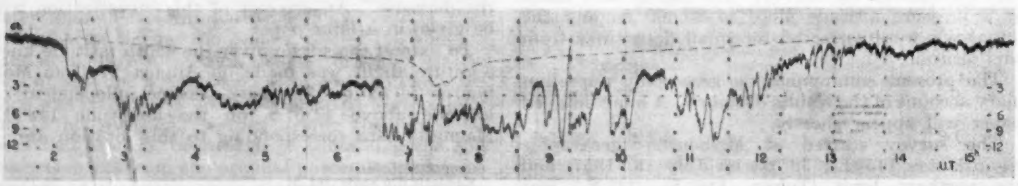

Fig. 1. Absorption of 18-Mc./s. cosmic noise during the auroral display of February 11, 1958, plotted against Universal Time

Table 1

t (days)	0	22·026	23·022	24·016	24·088	51·516	52·506
e	0·0973 ± 0·0004	0·0908 ± 0·0003	0·0905 ± 0·0003	0·0902 ± 0·0003	0·0902 ± 0·0003	0·0814 ± 0·0003	0·0811 ± 0·0003
T (min.)	103·49 ± 0·05	102·392 ± 0·001	102·342 ± 0·001	102·292 ± 0·001	102·289 ± 0·001	100·79 ± 0·02	100·73 ± 0·02
T/T_0 (calc.)	1	0·98955	0·98906	0·98856	0·98853	0·97405	0·97350
T/T_0 (obs.)	1	0·98939	0·98891	0·98842	0·98840	0·97391	0·97333

where C is a constant and $A' = A - 2\varepsilon R\sin^2\alpha$. Hence the result

$$A'\left(1 - \frac{t}{t_n}\right)^{-1/2} = \text{constant} \qquad (2)$$

follows, where t_n is the estimated 'life'. The correction term in A' is of the order of 21·7 miles for the orbit of Sputnik 2 (1957β) and implies a value of t_n of 152 days instead of the uncorrected 159 days, the time origin being November 9, 1957.

The best experimental check on the analysis is through the variation of the periodic time (T). Thus integrating equations (1) we find that :

$$\frac{T}{T_0} = 1 - \frac{3}{2}\left\{e_0 - \frac{2\varepsilon R\sin^2\alpha}{a_0}\right\}\left\{1 - \sqrt{1 - \frac{t}{t_n}}\right\} + \frac{3}{8}\frac{H}{a_0}\log\left(1 - \frac{t}{t_n}\right) + O(e_0^2)$$

(cf. Leslie[3]). From a series of values of the orbital elements we can obtain a fair estimate of t_n from (2), the alternative being to use the rate of decrease of periodic-time (cf. Scott[2]). A series of values of the orbital elements of Sputnik 2 is given in Table 1, the base time being 0522 G.M.T. on November 9, 1957. I estimate t_n as 151·95 days and then compute the ratio T/T_0, in this case without the term dependent upon H. The agreement with the observed values is to within 0·02 per cent and a reduction of T_0 by 0·02 min. (well within the probable error) would give agreement to four figures in all cases.

On an estimate of the scale-height at 135 miles as 10 miles, the magnitude of the term ignored is about that of the existing error. However, with a long sequence of orbital data it should be possible to obtain a reasonable estimate of H.

I thank Mr. D. G. King-Hele for the use of the unpublished data on the orbit of Sputnik 2.

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Microwave Spectrum of Nickel Cyclopentadienyl Nitrosyl and the Configuration of the Molecule

The volatile metallic nitrosyls have long been thought to contain linear (*metal*—N—O) arrangements, but on the basis of little positive evidence. The electron diffraction studies[1] of $Co(CO)_3NO$ and $Fe(CO)_2(NO)_2$ assume linearity of this grouping, and, while the results are in accord with this, it is not established that a non-linear structure would not fit equally well. The infra-red spectrum of $Co(CO)_3NO$ has also been assigned[2] on the basis of a linear arrangement, but it is doubtful if such spectra permit the exclusion of other configurations with certainty. It now seems accepted that more than one structure of the nitrosyl group in complexes is possible[3], and a bent Co—N—O grouping has been reported[4] from the X-ray study of a solid complex. In the case of nickel cyclopentadienyl nitrosyl, C_5H_5NiNO, moreover, a theoretical treatment of the bonding has been given[5], and we have therefore examined the microwave rotational spectrum of this substance.

Seven transitions of a strictly symmetric-top molecule, $C_5H_5{}^{58}NiNO$, were measured between 20,000 Mc./s. and 40,000 Mc./s., and yield the constants $B_0 = 1{,}259{\cdot}25$ Mc./s. and D_J = about 0·05 kc./s. The distortion constant D_{JK} is very small, K-splitting being unresolved, but B_0 may be very slightly in error since D_{JK} is taken as zero. Lines due to $C_5H_5{}^{60}NiNO$ were also measured at several transitions; for this species $B_0 = 1{,}258{\cdot}71$ Mc./s. No quadrupole fine-structures were detected. The location and intensities of other lines are in accord with their assignment to molecules in excited bending vibrational states, as would be expected.

The observed spectra can arise only if the Ni—N—O system is strictly linear, and forms an axis of symmetry normal to the C_5 and H_5 planes. In order to compute possible internuclear distances, we have assumed that the C_5H_5 group lies in one plane, that $d_{CC} = 1{\cdot}40$ A., as found in ferrocene[6] by X-ray diffraction, and that $d_{CH} = 1{\cdot}08$ A., and we have calculated d_{CNi} and d_{NiN} for a reasonable range of values of d_{NO} near the length believed to be present in the nitrosyl carbonyls[1]. For $d_{NO} = 1{\cdot}10 \pm 0{\cdot}03$ A., we find $d_{CNi} = 2{\cdot}107 \mp 0{\cdot}001$ A. and $d_{NiN} = 1{\cdot}676 \mp 0{\cdot}02$ A. It is thus very probable that d_{CNi} is less than the 2·18 A. given for this distance in nickelocene by electron diffraction[7]. This is acceptable, since C_5H_5NiNO is a stable complex, one of a series which probably contain eighteen metal valency electrons[5,8,9], while nickelocene has certainly a lower stability, attributable to the effect of two further, anti-bonding, electrons. In addition, the probable value of d_{NiN} is very low, being, for example, much less than the value of 1·87–1·90 A. found in nickel dimethyl glyoxime[10], which suggests that the NiN link in C_5H_5NiNO has considerable multiple bond character, as indicated by Orgel[5]. There is a possibility that the CH bonds are somewhat bent away from the nickel atom so that the C_5 and H_5 planes may not coincide, but this is unlikely to change the conclusions appreciably.

The parameters d_{NiN} and d_{NO} are determinable, without assumptions, with the aid of microwave spectra of species containing nitrogen-15 and oxygen-18, and we therefore plan to measure spectra of further isotopic forms.

An attempt, by similar methods, to establish the symmetry of $Co(CO)_3NO$ has, to date, failed to give conclusive results. The microwave spectrum of $Co(CO)_3NO$ is very weak, probably on account of

many low-lying vibrational levels. In C_5H_5NiNO the ring has the effect of restricting the number of low-frequency modes.

We wish to thank Prof. G. Wilkinson for his interest in this work, and for the gift of materials.

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Rectifying Effects of Sodium Chloride Crystals

Sodium chloride crystals were grown from the melt according to the Kyropoulos method. Part of the crystals was coloured electrolytically during growth, while other parts remained uncoloured. The specimens were 0·8 mm. thick and their area was about 3 mm.[2].

The current-voltage characteristics of such crystals were measured with a simple series circuit. One side of the crystals was coated with gold by evaporation *in vacuo* and placed in contact with a platinum plate, which acted as a low-resistance base electrode. The other electrode used in these experiments was prepared from a platinum wire 0·2 mm. in diameter one end of which has been filed to a point or from a tungsten wire 0·1 mm. in diameter, brought electrolytically to a fine cone at one end. There were no detectable differences in the results of measurements made with these two sorts of point electrode.

Sodium chloride crystals behave as insulators at room temperature; at elevated temperatures, however, their conductivity changes in accordance with van 't Hoff's law. The measurements were carried out at 250° C., at which temperature the specific conductivity of the crystals is about $10^{9}\ \Omega^{-1}$ cm.$^{-1}$.

In Fig. 1, curve *a* refers to a coloured crystal, curve *b* to an uncoloured specimen. Measuring the current-voltage characteristic in the forward direction with crystals at a positive potential with respect to the point-electrode, the shapes of the characteristic of the coloured and uncoloured crystals are very similar. Rectification ratios (at 100 volts) obtained for coloured crystals are about 30 : 1; for uncoloured specimens this ratio was about 15 : 1 at the same voltage. For both coloured and uncoloured crystals the ratio of the forward to the reverse resistance decreases with increasing voltage.

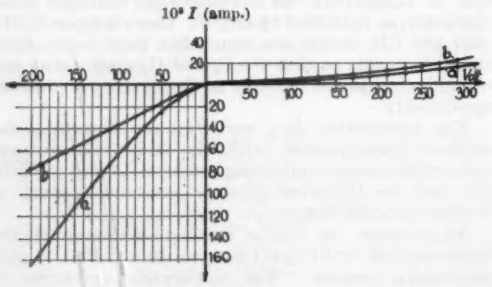

Fig. 1

A prolonged current in the reverse direction (when the crystal is negative relative to the point contact) increases the reverse resistance, and at the same time the forward resistance changes so as to increase the rectification ratio for both coloured and uncoloured specimens. A strong forward current, on the other hand, decreases the forward resistance as well as the reverse resistance, so that the rectification ratio is reduced. The curves (Fig. 1) refer to crystals which have been subjected to a reverse current at 400–500 volts.

As a result of repeated measurements on the same crystals, colour centres are formed around the point contact, which migrate towards the plate electrode.

I wish to thank Prof. Z. Gyulai, director of this Institute, Dr. J. Boros and Dr. P. Tomka for valuable discussions, and B. Jeszenszky and J. Kiss, who grew the crystals for these investigations.

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An Optical Method of obtaining the Frequency Response of a Lens

The image-forming properties of many types of lens have been measured in this laboratory, with particular reference to their suitability for use in television equipment such as cameras, film scanners, telerecorders, etc. The spatial frequency response of a lens is one of the most important characteristics to be determined; and the basic photoelectric methods of measuring this response function have been largely developed in Britain by Sproson[1].

The particular method we have used for the past two years consists of measuring the lateral intensity distribution of the image formed by the lens when an incoherently illuminated narrow slit is used as the test-object. (The method is analogous to the unit impulse method of testing four-terminal electrical networks.) The intensity distribution is recorded automatically, but the Fourier transform to obtain the frequency response is carried out by a computational procedure using a calculating machine. Although this method yields a high degree of accuracy, the computational work involved in the transform of the space functions can be tedious, especially when a lens is tested in detail over its working field. Attention has been focused recently on test apparatus for obtaining the frequency response automatically and directly: several ways of doing this[2] have been suggested, which mostly involve either continuous scanning mechanisms or reciprocating components. The Fourier transform can be carried out, however, solely by optical means in a very simple and elegant manner. The proposed method of instrumentation is based on a device due to Born *et al.*[3].

Fig. 1 shows the layout of the apparatus. A long, narrow slit test-object is illuminated incoherently by

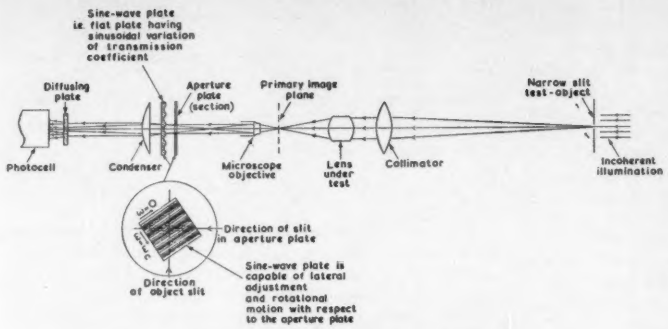
Sine-wave plate i.e. flat plate having sinusoidal variation of transmission coefficient
Diffusing plate
Aperture plate (section)
Primary image plane
Narrow slit test-object
Photocell
Condenser
Microscope objective
Lens under test
Collimator
Incoherent illumination
Direction of slit in aperture plate
Sine-wave plate is capable of lateral adjustment and rotational motion with respect to the aperture plate
Direction of object slit

Fig. 1. Layout for a lens-testing bench

a tungsten light source. A good-quality collimator serves to place the object virtually at infinity with respect to the lens under test. The primary image formed is relayed by a microscope objective to a second image plane in which is placed a sine-wave plate or transparency. Immediately in front of this plate is fixed a long narrow slit aperture oriented at right angles to the object slit. The light flux emerging from this aperture passes through the sine-wave plate and is integrated by collecting the light on to the photo-cathode of a photocell.

It can be shown that the photocell output is given (apart from an additional constant term) by,

$$K \int_{-a}^{b} F(x) \cos(\omega x + \delta)\, dx \qquad (1)$$

where $F(x)$ represents the continuous lateral intensity distribution of the image, which is always real, positive and continuous over a finite range, $-a$ to b, and either zero or constant outside this range; $\omega/2\pi$ is the spatial frequency of the transmission function of the sine-wave plate in the x-direction (along the narrow slit aperture in the image plane); and δ is a phase constant.

Clearly, the complete Fourier transform of $F(x)$

$$K \int_{-a}^{b} F(x) \exp(-i\omega x)\, .\, dx \qquad (2)$$

is readily determined if the integral (1) is known for any two values of δ separated by $\pi/2$.

The spatial frequency is continuously varied over the range 0 to $\omega_c/2\pi$ (where ω_c is the maximum angular frequency of the sine-wave plate) simply by rotating the plate in its own plane relative to the fixed slit aperture about an axis which always passes through the centre of the aperture. The phase constant, δ, can be adjusted by a lateral movement of the sine-wave plate relative to its own axis of rotation. The most useful feature of the device lies in the fact that the spatial frequency, $\omega/2\pi$, can be varied by a pure rotation without altering the pre-selected value of the phase constant δ. In practice the values $\delta = 0$ and $\delta = \pi/2$ would normally be selected. These correspond to the two cases where the axis of rotation intersects the sine-wave plate at points of maximum and mean transmission respectively. Thus the cosine and sine components of the transform are obtained from which the modulus and phase are readily deduced. In a large number of cases with well-corrected lenses the sine component of the transform is often small enough to be neglected.

Using the present scanning method, corrections are applied to the modulus of the transform because of the finite widths of the object and scanning slits. An interesting feature of this direct integrating method is that no overall correction for the finite slit widths is required, providing that: (*a*) the widths of slits (namely, the object slit and the perpendicular aperture slit when referred to the same plane) are equal; and (*b*) the width of the slits does not greatly exceed $\pi/2\omega_c$. It can be shown that, for any given width up to $\pi/2\omega_c$, the product of the respective correction factors for the two slits does not vary from constancy by more than 0·1 per cent. A further valuable feature is that, since the measured spatial frequency-range is independent of the magnification of the lens under test, only one accurately made sine-wave plate, covering the desired range, is needed.

The accuracy of the method will probably be limited by the lack of perfection of the sine-wave plate performing the analysis, but it permits a very practical and simple photoelectric lens-testing bench to be constructed which could rapidly give the essential information about the frequency response of a lens.

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A Nail found within a Hen's Egg

On the morning of January 1, 1957, we sat down together for breakfast; one of us (G. T. K.) removed the shell from the blunt end of her four-and-one-half-minute egg, and added salt and pepper to the exposed albumin. A moment later my wife and I looked with amazement at an object which she had removed from her mouth under the impression that it was a bit of shell. This object was a sharp, clean nail of the type frequently known as a brad about 1·5 cm. long. While it is not possible to state precisely in which layer of albumin the nail occurred, it undoubtedly lay in the chalaza fairly close to the shell membrane.

As a biologist only moderately familiar with the idiosyncrasies of the avian egg, the other author (H. K.) immediately examined the possibility that the nail was not in the egg before the partial removal of the shell; this in spite of the fact that the entire operation had been performed under his casual but direct observation. Since no grounds for accepting such a possibility were discovered, our next step was to examine the literature for a precedent.

Apart from inclusions of endogenous origin, for example, blood clots, bits of ovary, concretions, small eggs or remnants of broken eggs, quite a number of

objects of environmental origin are recorded as having been observed within the hen's egg; for example, flukes, roundworms and insects; feathers, horsehair and fæcal matter; sand, pebbles and even a coffee bean. Many of these were described by Bonnet[1] and are included in the brief discussion given by Romanoff and Romanoff[2]. However, the only object at all similar to the one described here was observed about 275 years ago by Perrault[3]. This object was a metal pin in the shape of a frog's thigh bone; under a whitish crust, it was black and slightly rusted. Perrault was of the opinion that the pin reached the egg after having penetrated the intestinal and oviducal walls. Romanoff and Romanoff suggest that "inanimate foreign bodies of extraneous origin are probably picked up when part of the hen's oviduct is everted as an egg is laid, and are then passed up the oviduct by means of antiperistaltic contractions". Essentially the same explanation is offered by Bonnet.

How our particular nail entered the egg we leave to the speculations of biologists more schooled in such matters, although of the two possibilities listed above we must admit to some bias in favour of the earlier one by Perrault.

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Subjective Probability, Gambling and Intelligence

In a communication in *Nature*,[1] Mr. H. C. A. Dale[1] made some interesting suggestions about the relationship between subjective probability, intelligence and the tendency to gamble. Certain experiments of our own in the realm of subjective probability may throw further light on this complex question.

In a recent experiment, as yet unreported, we gave our subjects the opportunity of choosing between: (i) a single packet of sweets, or (ii) a one in five chance of winning five packets, or (iii) a one in twenty-five chance of winning twenty-five packets. The subjects consisted of three groups of schoolchildren aged 9, 12 and 15 years respectively. Each age-group consisted of upper and lower 'streams' differentiated on the basis of ability and attainment as shown in the school records.

We found that 81 per cent of all the children preferred the uncertainty of winning a larger prize to the certainty of a smaller one. This tendency, as shown in Table 1, diminished with increase in age ($P < 0.001$).

Table 1. Preferences at Different Ages

Age (years)	Certain	1 in 5	1 in 25	Total
9	4	22	40	66
12	8	28	26	62
15	23	20	7	50
Total	35	70	73	178

Table 2. Preferences for Certain or Uncertain Prize in the Age-Groups Combined

	Upper 'streams'	Lower 'streams'	Total
Certain prize	12	23	35
Uncertain prize	84	59	143
Total	96	82	178

But we cannot attribute this weakened tendency to gamble to increased ability with age because, as shown in Table 2, the proportion of the children preferring the uncertain larger prize is greater in the upper than in the lower 'streams' at each age ($P < 0.02$).

Although the uncertain prize is preferred by children in the upper 'streams', their preference is for a small gamble rather than for a large gamble. The differences between the 'streams', as shown in Table 3, are significant ($P < 0.02$).

Table 3. Preferences for Short or Long Odds

	Upper 'streams'	Lower 'streams'	Total
1 in 5	48	22	70
1 in 25	36	37	73
Total	84	59	143

In a true gambling situation, if one prize is certain, provided it is large enough in relation to the individual's scale of values, almost everyone will prefer it, however much larger the uncertain prize; and vice versa, if the certain prize is negligible, the uncertain but worthwhile prize will be preferred. At intermediate values of the certain prize, the preference for it will be weighed against the subjective probability of winning the large prize, and this subjective probability will vary from person to person and be affected by age. Thus in our results, a relatively higher proportion of the younger subjects prefer the gamble, presumably because their subjective probability of winning the uncertain prize is relatively greater than in the case of the older children.

There are three more general considerations to which we would direct attention in respect of the relationship between subjective and mathematical or statistical probabilities. In the first place, the relationship is complex and cannot be reduced to a simple formula. In certain circumstances the two types of probability tend to coincide; in other circumstances they diverge and this divergence seems to be of a systematic nature[2]. Secondly, subjective probabilities are, in general, very much influenced by age and experience. Thirdly, the subjective probability relating to any particular preference expressed is affected by the number and value of alternatives offered[3].

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FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, April 21

BRITISH SOCIETY FOR THE HISTORY OF SCIENCE, PHILOSOPHY OF SCIENCE GROUP (in the Joint Staff Common Room, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. A. R. Ubbelohde, F.R.S.: "Metametrics or the Limits of Science".

SOCIETY OF CHEMICAL INDUSTRY, PESTICIDES GROUP (at 14 Belgrave Square, London, S.W.1), at 5.30 p.m.—ANNUAL General Meeting.

BRITISH COMPUTER SOCIETY (at York Hall, Caxton Hall, Westminster, London, S.W.1), at 6.15 p.m.—Dr. Frank Yates, F.R.S.: "The Use of an Electronic Computer in Research Statistics—Four Years' Experience".

INSTITUTE OF METAL FINISHING (at the Northampton Polytechnic, St. John Street, London, E.C.1), at 6.15 p.m.—Mr. R. R. Benham: "Silver Plating with particular reference to Silver Anodes".

WOMEN'S ENGINEERING SOCIETY, LONDON BRANCH (at the Central Electricity Authority Headquarters, Winsley Street, London, W.1), at 6.45 p.m.—Wing Commander P. M. Chettle: "Philosophy of Guided Missile Design".

Tuesday, April 22

ROYAL SOCIETY OF ARTS, COMMONWEALTH SECTION (at John Adam Street, Adelphi, London, W.C.2), at 5.15 p.m.—Brigadier Martin Hotine, C.M.G., C.B.E.: "Overseas Surveys".

Wednesday, April 23

ROYAL METEOROLOGICAL SOCIETY (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Annual General Meeting. Prof. P. A. Sheppard: "Transfer Across the Earth's Surface and Through the Air Above" (Presidential Address).

INSTITUTION OF ELECTRICAL ENGINEERS, RADIO AND TELECOMMUNICATION SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. D. E. L. Shorter: "Survey of Performance Criteria and Design Considerations in High-Quality Monitoring Loudspeakers".

CHALLENGER SOCIETY (at the Linnean Society, Burlington House, Piccadilly, London, W.1), at 5.45 p.m.—Annual General Meeting, followed by Dr. R. Cox: "The Electric Salinity Meter—an Appraisal of the Present Situation"; Dr. E. Denton: "The Buoyancy of Deep-Sea Fish which have no Gas Filled Swim Bladder".

INSTITUTION OF MECHANICAL ENGINEERS, EDUCATION GROUP (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Discussion on "Teaching the Fundamentals of Automatic Control".

SOCIETY OF CHEMICAL INDUSTRY, FOOD GROUP (at 14 Belgrave Square, London, S.W.1), at 6.15 p.m.—Mr. C. F. Timberlake: "Metal Complexes in Fruit Juices"; Mr. A. E. Joyce: "Some Observations on Plant Carotenoids with particular reference to their Stability in Food Preservation".

BRITISH INSTITUTION OF RADIO ENGINEERS (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 6.30 p.m.—Mr. R. J. Cox, Mr. D. Harrison and Mr. R. B. Stephens: "A Reactor Transfer Function Analyser". ▶

INSTITUTE OF FUEL (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 6.30 p.m.—Mr. H. McNeil: Presidential Address.*

Thursday, April 24

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Mr. J. A. Allen: "On the Basic Form and Adaptations to Habitat in the Lecinacea (Eulamellibranchia)"; Mr. T. E. Thompson: "The Natural History, Embryology, Larval Biology and Post-larval Development of *Adalaria proxima* (Alder and Hancock) (Gastropoda Opisthobranchia)".

AUSTRIAN INSTITUTE (at 28 Rutland Gate, London, S.W.7), at 6 p.m.—Prof. Dr. B. Karlik (Institut für Radiumforschung und Kernphysik der Österreichischen Akademie der Wissenschaften): "Nuclear Sciences and Atomic Energy in Austria".

SOCIETY OF CHEMICAL INDUSTRY, LONDON SECTION (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Dr. C. Bertoni: "Some Aspects of Italian Chemical Industry".

INSTITUTION OF ELECTRONICS (in the Assembly Hall, University of London Institute of Education, Malet Street, London, W.C.1), at 7 p.m.—Dr. F. G. Smith: "Radioastronomy and the Sputniks".

Friday, April 25

INSTITUTE OF NAVIGATION (at the Royal Geographical Society, 1 Kensington Gore, London, S.W.7), at 5.15 p.m.—Discussion on "The Use of Simulators for Training Navigators to Use Radar Equipment".

UNIVERSITY COLLEGE (in the Physiology Theatre, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. B. Delisle Burns (McGill University): "Networks of Self-reexciting Neurones"*. (Further lecture on April 29.)

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT LECTURER or LECTURER IN THE DEPARTMENT OF MECHANICAL ENGINEERING—The Registrar, The University, Liverpool (April 26).

LECTURER (honours graduate of a British university, and capable of teaching one branch of chemistry (preferably inorganic or analytical) to the standard of B.Sc. and the final examination of the Royal Institute of Chemistry) IN THE SCIENCE DEPARTMENT, to teach chemistry—The Principal, Stockport College for Further Education, Wellington Road South, Stockport (April 26).

LECTURER IN CIVIL ENGINEERING—The Registrar, The University, Sheffield (April 28).

ASSISTANT LECTURER (with a good honours degree) IN PURE MATHEMATICS—The Registrar, King's College, Strand, London, W.C.2 (April 30).

ASSISTANT (with a university degree in botany, and preferably a knowledge of economic botany and an aptitude for the factual presentation of the subject to the public) IN THE DEPARTMENT OF BOTANY—The Director, Liverpool Public Museums, Carnatic Hall, Elmswood Road, Liverpool 18 (April 30).

FELLOW IN CHEMISTRY or BIOCHEMISTRY, for work on organic and biochemical aspects of bacterial cell walls—The Registrar, King's College (University of Durham), Newcastle-upon-Tyne (April 30).

LECTURER (with an honours degree in mathematics and experience in numerical methods and programming high-speed digital computers) IN COMPUTING in the Department of Mathematics—The Recorder, The College of Aeronautics, Cranfield, Bletchley, Bucks (April 30).

LECTURERS IN ORGANIC CHEMISTRY and in PHYSICAL CHEMISTRY, and an ASSISTANT LECTURER IN CHEMISTRY—The Registrar, The Manchester College of Science and Technology, Manchester 1 (April 30).

LECTURERS (preferably with a special interest in thermodynamics) IN MECHANICAL ENGINEERING—The Secretary of University Court, The University, Glasgow (April 30).

ASSISTANT LECTURER, Grade B, TO TEACH CHEMISTRY AND PHYSICS mainly to day classes preparing for G.C.E. "O" level—The Principal, North Lindsey Technical College, Kingsway, Scunthorpe, Lincs (May 2).

ASSISTANT EXPERIMENTAL OFFICER (graduate botanist or horticulturist), to work on plant variability in the Statistics Section—The Secretary, East Malling Research Station, Maidstone, Kent (May 3).

ASSISTANT LECTURER IN THE DEPARTMENT OF AGRICULTURE (CROP HUSBANDRY)—The Registrar, University College of Wales, Aberystwyth (May 3).

JUNIOR RESEARCH FELLOW IN PURE MATHEMATICS—The Registrar, The University, Sheffield (May 3).

RESEARCH FELLOW, and a RESEARCH ASSISTANT, IN THE DEPARTMENT OF BOTANY, to undertake a survey of the nutritive requirements of the excised roots of different species and varieties—The Registrar, University College, Singleton Park, Swansea (May 3).

ASSISTANT LECTURER IN PHARMACOLOGY—The Registrar, The University, Nottingham (May 10).

LECTURER or ASSISTANT LECTURER (with a higher degree in biochemistry, physiology or pharmacology) IN BIOCHEMISTRY in the Department of Comparative Physiology and Biochemistry—The Secretary and Registrar, The University, Southampton (May 10).

COURTAULD CHAIR OF ANIMAL HUSBANDRY AND VETERINARY HYGIENE in the Royal Veterinary College—The Academic Registrar, University of London, Senate House, London, W.C.1 (May 12).

CHAIR OF AGRICULTURE—The Secretary, The University, Aberdeen (May 16).

LECTURER IN INORGANIC CHEMISTRY—The Secretary, The Queen's University, Belfast (May 20).

CHAIR OF APPLIED MATHEMATICS in the University of Malaya, Singapore—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (June 9).

LECTURER or ASSISTANT LECTURER IN MATHEMATICS at the University of Malaya, Singapore—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (June 9).

LECTURER (preferably with an interest in vertebrate zoology) IN ZOOLOGY at the University College of Ghana—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (June 15).

ASSISTANT LECTURER IN PHYSICS—The Clerk to the Governors, Northern Polytechnic, Holloway, London, N.7.

ASSISTANT LECTURER IN THE DEPARTMENT OF NATURAL PHILOSOPHY—The Secretary, Royal College of Science and Technology, Glasgow.

ASSISTANT LECTURERS IN (*a*) ORGANIC or (*b*) PHYSICAL CHEMISTRY—The Secretary, Royal College of Science and Technology, Glasgow.

GEOLOGIST (with a first- or upper second-class honours degree in geology which has included mining geology as a subject, and at least ten years' postgraduate experience of geology and valuation of mines, and mineral prospecting and surveys by modern techniques) IN THE GEOLOGICAL SURVEY DEPARTMENT, Government of Tanganyika, to record the geology of producing mines, inspect and record the operations of companies engaged in prospecting and mineral surveys under licence, and to examine and appraise mineral deposits, prospects and mines—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.105/8/03/T.

LABORATORY TECHNICIAN (with G.C.E. science and mathematics, preferably at advanced level, or laboratory qualifications in physiology) IN THE PHYSICS DEPARTMENT, to assist in physiology research—The Secretary, St. Mary's Hospital Medical School, Paddington, London, W.2.

MASTERS TO TEACH PHYSICS AND CHEMISTRY to open scholarship standard—The Headmaster, Berkhamsted School, Herts.

PHYSICIST (preferably with experience in radioisotopes), to supervise the routine isotope laboratory in the Medical Physics Department—The Secretary, Bristol General Hospital, Guinea Street, Bristol 1.

REPORTS and other PUBLICATIONS

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Great Britain and Ireland

Eisenhower to Bulganin: Texts of President Eisenhower's Letters of January 12 and January 20 to Mr. N. A. Bulganin, Chairman of the Council of Ministers of the U.S.S.R. Pp. 7. (London: United States Information Service, 1958.) [42

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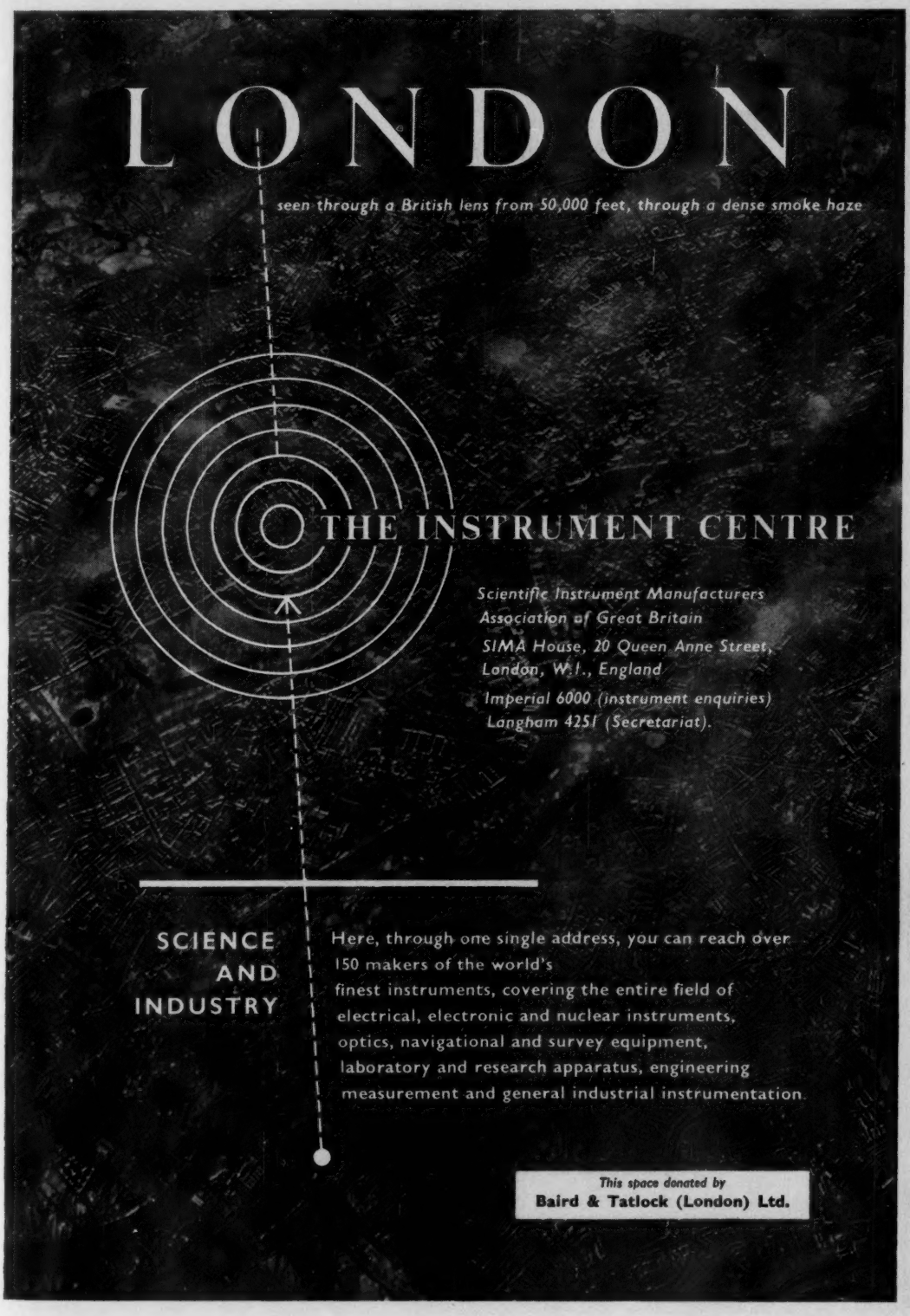
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